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CH-53A FLEXIBLE FRAME VIBRATION ANALYSIS/TEST CORRELATION

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By

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ABSTRACT

The Sikorsky Finite Element Airframe Vibration Analysis (Fran/Vibration Analysis) has been found to correlate well with data taken in shake tests of the CH-53A. The frequencies of fundamental fuselage bending and transmission modes were predicted by the FRAN/Vibration Analyses to an average accuracy of three percent. In addition, the mode shapes were defined accurately.

Dynamic modeling techniques have been developed that are applicable to all finite element dynamic analyses. These include: selection of static and dynamic degrees of freedom, cockpit structural modeling extent of flexible frame modeling in the transmission support region, and sub-structuring of the dynamic model.

A modular approach to modeling has been introduced in which subdivisions of the aircraft are modeled individually. Applying this modular approach to the FRAN/Vibration analysis permits accurate predictions of significant changes in the character and frequency of fuselage and transmission modes due to changes in mass distribution and structural characteristics.

The modeling techniques and analysis used in this study can be applied during helicopter design and during evaluation of growth versions of current aircraft. These techniques, in combination with an accurate definition of the vehicle's structural characteristics, will enable accurate prediction of all transmission and fuselage modes for a vehicle without a cargo ramp.

It is recommended that full-scale shake tests and correlation should be continued to improve modeling techniques for fuselages that include cargo ramps and for such items as the main rotor, main rotor shaft, tail pylon and sponsons. Upon completion, a correlation between predicted CH-53A in-flight vibration levels and data recorded during the NASC supported CH-53A rotor loads program should be performed. It is further recommended that an integrated structural design system coupling stress and dynamic analyses be developed to provide the designer with the structural details required for vibration analysis and control early in the helicopter design process.

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1.0 INTRODUCTION

Helicopter vibration and resulting aircraft vibratory stress can lead to costly schedule slippages as well as field service maintenance and aircraft availability problems. At the core of vibration control technology is the requirement to rapidly and accurately design the helicopter structure so that its response to rotor excitations is minimized.

The helicopter is a complex structure consisting of sections which differ considerably in structural arrangement and load carrying requirements. These include the cockpit, cabin, tail cone and tail rotor pylon. In addition, large fuselage cut-outs and concentrated masses such as the transmission, main rotor and tail rotor which are unique to helicopters play a major role in controlling vibrations.

The complexity of the helicopter structure, combined with increasingly stringent mission and vibration control requirements, demands the development of airframe structural vibration analyses which can be rapidly and economically used to evaluate and eliminate vibration and airframe stress problems during the preliminary design phase of helicopters.

Although detailed analytical methods based on finite element techniques have been developed for studying the vibratory characteristics of complex structures, a detailed correlation of such methods with test data is not available in the general literature. Further, little or no information is available as to the accuracy of various modeling assumptions which might be made to reduce the cost and time of applying the vibration analysis.

2.0 OBJECTIVES

The objective of this investigation was to use the Sikorsky Finite Element Vibration Analysis (FRAN/Vibration Analysis) to:

(a) Determine the accuracy of the FRAN/Vibration analysis in predicting the vibration characteristics of complex helicopter airframe structures.

and

(b) Develop and evaluate general helicopter dynamic modeling techniques that could be used to provide accurate estimates of vehicle dynamic characteristics while at the same time minimizing the complexity (and, hence, cost) of the analysis.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

3.1.1 Correlation

a) The FRAN/Vibration Analysis can accurately predict the frequencies and mode shapes of complex, helicopter structures provided that the structural data base required for the analysis is accurately defined.

b) The analysis provided excellent prediction of the transmission and fuselage modes which were not controlled by the rear cargo ramp cut-out.

c) Less satisfactory correlation of higher frequency ramp - controlled modes is attributed to limitations in the available number of dynamic degrees of freedom in the current version of the program and the method of testing employed, which did not adequately decouple higher frequency modes.

d) Significant changes in the character and frequency of fuselage and transmission modes due to changes in mass distributions and structural characteristics can be predicted accurately.

3.1.2 Modeling

a) No degradation in accuracy results from selecting static degrees of freedom which are based upon a structural model that contains lumped stringers numbering one-half the actual number of stringers.

b) No more than sixteen dynamic degrees of freedom on each flexible frame are required for dynamic modeling.

c) Prediction of airframe modes is insensitive to modeling of the cockpit and forward fuselage structural stiffness.

d) A flexible frame representation of the transmission support region extending about 1.5 transmission lengths forward and aft of the corresponding transmission supports is adequate for predicting fuselage and transmission modes of a vehicle without a rear cargo ramp cut-out.

e) Predictions for a vehicle with a rear cargo ramp require a mathematical model that includes a flexible frame representation spanning about 1.5 transmission lengths forward of the transmission supports through and including the rear cargo ramp cut-out.

4.0 Description of Analysis (continued)

The PPFRAN program is a stiffness method finite element analysis which is primarily designed for application to single cell semi-monocoque structures, typical of a helicopter fuselage. The program is based upon the IBM/MIT Structural Analysis program FRAN (Reference No. 1) which is a finite element procedure originally designed for application of civil engineering framed structures. It is limited to two types of elements namely bars and rods. Subsequently, FRAN has been further developed by Sikorsky Aircraft for application to airframe stressed skin structures.

This development consists of the addition of Pre and Post operative procedures linked to FRAN. In the pre-operative procedure routine (Pre-FRAN), the fuselage skin is transformed into an equivalent framed structure, and all input data is reassembled in terms of this structure into the FRAN input format. The "equivalent frame" model is based upon an equivalent internal energy criterion.

In order to analyze a stressed skin structure by use of FRAN, the skin panels must first be transformed into equivalent rod elements. The transformation which simulates the fuselage skin by diagonal rods is developed by satisfying the criterion that the internal energy of the skin structure under a given set of loads is the same as that of the transformed structure under the same set of loads.

Consider the panel with its framing members shown in Figure 2 subjected to an arbitrary set of loads at its node points. Certain of these loads may be regarded as reactions, the rest as producing deflections relative to these reactions. Considering P6 through P8 as reactions, the internal strain energy (U) of the structure can be expressed in terms of loads P_1 through P_5 and the physical properties of the structure. Replacing the skin panel by diagonal rod elements, the transformed structure is also shown in Figure 2. Considering the reactions and applied loads to be the same as on the original skin panel and assuming the loads in the diagonal rods to be equal and opposite, the internal energy of the framed structure (U) may again be expressed in terms of the applied loads and the physical properties of the structure.

The two energy expressions are:

$$U = \tfrac{1}{2}\lfloor P \rfloor \left[a_{ij} \right] \{P\}$$
$$U' = \tfrac{1}{2}\lfloor P \rfloor \left[a_{ij}' \right] \{P\}$$

4.0 DESCRIPTION OF ANALYSIS

A study of shake test data recorded at Sikorsky Aircraft indicates that the natural modes of vibration of a helicopter may be categorized in terms of

(1) Modes controlled by overall fuselage characteristics

and

(2) Modes controlled by the transmission support structure's characteristics

The Sikorsky Airframe Vibration Analysis places special emphasis on accurately defining the transmission modes. Their frequencies are generally in proximity to N/Rev (blade passage frequency) and therefore play a principal role in controlling the vibration environment. Consequently, the mathematical modeling of the transmission area will contain the greatest detail.

The transmission support controlled modes can be classified as vertical, pitch and roll and are principally controlled by the flexibility of the structure in the transmission support region. This region has the following properties:

a) Its principal structure, frames, have the major effect on transmission modes.

b) It carries large concentrated loads generated by the transmission, rotor head, engines, sponsons and cargo.

c) Its vibratory motion is characterized by elastic deformation of the frame envelope or periphery.

The overall helicopter structure is therefore modeled utilizing two basic modules:

1) The center section or transmission support region.

2) a. The forward fuselage and cockpit

   b. The aft fuselage and tail.

Each of these modules has unique physical properties. The mathematical model, utilizing a modular approach permits the use of different representations for each substructure.

The center section is modeled in the greatest detail through the application of the PPFRAN program. The model of the center section is assumed to be supported at the transmission tie down points, the end frames are assumed to be rigid so that the motion of these frames can be described at a single point in the plane of the frame and can be utilized to marry this section of the fuselage to the remaining modules. All influence coefficients are computed

4.0 DESCRIPTION OF ANALYSIS (continued)

relative to the support points. Their use in performing the dynamic analysis will be discussed below.

The structural characteristics of the remaining modules are derived from beam theory. The model of the aft and forward modules are cantilevered at the respective forward and 't ends of the transmission support region. Additional internal cantilever points can be utilized to divide these modules into smaller sub-structures. All influence coefficients are computed relative to the next cantilever point or relative support point. The greater the number of relative support points or sub-structures, the less the coupling that exists within the influence coefficient matrix. This provides for reduced input, greater ease of error checking, and facilitates modifications to local structural properties with minimum modification to the influence coefficient matrix. Sub-structuring in this manner also facilitates the addition of appendages since only the influence coefficients relative to the attachment point of the appendage are required. An example of this sub-structure method and its effect on the band width of the influence coefficient matrix is illustrated in Figure 1.

Thus the PPFRAN program is utilized to define the influence coefficients of the center section relative to the transmission supports and beam theory is applied to define the influence coefficients of all remaining substructures relative to their individual supports. The 200 degree of Freedom Free Vibration analysis then combines these influence coefficients, the mass distribution and appropriate coordinate transformations to determine the free vibration characteristics of the structure.

4.0 Description of Analysis (continued)

The PPFRAN program is a stiffness method finite element analysis which is primarily designed for application to single cell semi-monocoque structures, typical of a helicopter fuselage. The program is based upon the IBM/MIT Structural Analysis program FRAN (Reference No. 1) which is a finite element procedure originally designed for application of civil engineering framed structures. It is limited to two types of elements namely bars and rods. Subsequently, FRAN has been further developed by Sikorsky Aircraft for application to airframe stressed skin structures.

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In order to analyze a stressed skin structure by use of FRAN, the skin panels must first be transformed into equivalent rod elements. The transformation which simulates the fuselage skin by diagonal rods is developed by satisfying the criterion that the internal energy of the skin structure under a given set of loads is the same as that of the transformed structure under the same set of loads.

Consider the panel with its framing members shown in Figure 2 subjected to an arbitrary set of loads at its node points. Certain of these loads may be regarded as reactions, the rest as producing deflections relative to these reactions. Considering P6 through P8 as reactions, the internal strain energy (U) of the structure can be expressed in terms of loads P_1 through P_5 and the physical properties of the structure. Replacing the skin panel by diagonal rod elements, the transformed structure is also shown in Figure 2. Considering the reactions and applied loads to be the same as on the original skin panel and assuming the loads in the diagonal rods to be equal and opposite, the internal energy of the framed structure (U) may again be expressed in terms of the applied loads and the physical properties of the structure.

The two energy expressions are:

$$U = \tfrac{1}{2}[P][a_{ij}]\{P\}$$
$$U' = \tfrac{1}{2}[P][a'_{ij}]\{P\}$$

4.0 Description of Analysis (Continued)

where

$i = 1, 2, \text{-------} 5$

a_{ij}' = Influence coefficients of original structure. Displacement at P_i relative to the chosen reactions due to a unit load at P_j .

and a_{ij} = Influence coefficients of transformed structure relative to reaction loads.

4.0 Description of Analysis (continued)

Equating these energies we obtain:

$$A_5' = \frac{2L^3}{\eta} = \text{cross sectional area of each diagonal.}$$

where:

$$\eta = \frac{4deE}{t\,G} + \frac{d^3}{3}\left(\frac{1}{A_1} + \frac{1}{A_4}\right) + \frac{e^3}{3}\left(\frac{1}{A_2} + \frac{1}{A_3}\right)$$

$$L = \sqrt{e^2 + d^2}$$

and

$$A_1' = A_1$$

$$A_2' = A_2$$

$$A_3' = A_3$$

$$A_4' = A_4$$

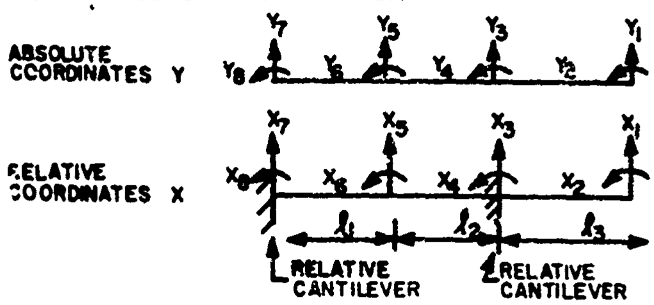
Utilizing the above transformation, the fuselage skins are replaced by the diagonal rod elements, each of area A_5', other framing members remaining unchanged. This transformation provides the structure which is analysed by FRAN.

The post-operative routine (Post-FRAN) interprets the results of the FRAN analysis in terms of the original stressed skin structure and can provide member and panel loads and stresses as well as the influence coefficient matrix required for dynamic analysis. This influence coefficient matrix is the inverse of the reduced stiffness matrix utilized in the dynamic analysis contained within recently developed general purpose finite element analyses.

The complete package (PPFRAN) is fully automated and operational. It has been successfully correlated against static test data to demonstrate, the programs ability to accurately predict stresses and influence coefficients for an aircraft fuselage type structure (Reference No. 2).

4.0 Description of Analysis (Continued)

As described previously, all influence coefficients are defined in a relative coordinate system. This procedure is utilized since the influence coefficient matrix of a free-free structure, a helicopter in flight, does not exist. The proof that this matrix does not exist is quite simple. The stiffness matrix of a free-free structure is singular, the inverse of any singular matrix does not exist. The motions of the structure in its free modes of vibration are desired in absolute coordinates and thus the mass matrix of the structure being analyzed is defined in an absolute coordinate system. The two coordinate systems can be related through a simple geometric transformation matrix. These three matrices; Relative Influence Coefficients, Absolute Mass and Coordinate Transformation are all that is required by the Vibration Analysis. Consider the following example of the free-free vibrations of a beam.



The last numbered coordinates are defined as the ignorable coordinates. It is assumed that the absolute and relative motion of the ignorable coordinates are identical. Thus the relations:

$$Y_7 = X_7$$

and

$$Y_8 = X_8$$

In the case of a complete helicopter analysis the ignorable coordinates are the six degrees of freedom located at the center of the base of the transmission.

4.0 Description of Analysis (Continued)

The relative influence coefficient matrix of the sample structure is

$$\left[\alpha_{ij}\right] = \begin{array}{c|cccccccc} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ \hline 1 & X & X & & & & & & \\ 2 & X & X & & & & & & \\ 3 & & & X & X & X & X & & \\ 4 & & & X & X & X & X & & \\ 5 & & & X & X & X & X & & \\ 6 & & & X & X & X & X & & \\ 7 & & & & & & & & \\ 8 & & & & & & & & \end{array}$$

The mass matrix for absolute degrees of freedom 1 - 8 are defined as the appropriate values of masses and moments of inertia. This matrix is therefore diagonal.

The absolute motions can then be defined in terms of relative motions by the following equations.

$$Y_1 = X_1 + X_3 + X_7 + X_4 \ell_3 + X_8 (\ell_1 + \ell_2 + \ell_3)$$

$$Y_2 = X_2 + X_4 + X_8$$

$$Y_3 = X_3 + X_7 + X_8 (\ell_1 + \ell_2)$$

$$Y_4 = X_4 + X_8$$

$$Y_5 = X_5 + X_7 + X_8 \ell_1$$

$$Y_6 = X_6 + X_8$$

$$Y_7 = X_7$$

$$Y_8 = X_8$$

Thus the absolute motions are defined in terms of the relative motions by the transformation equations.

$$\{Y\} = [T] \{X\}$$

4.0 Description of Analysis (Continued)

The free-free equations of motion in absolute coordinates are defined by the equations of motion.

$$[M]\{\ddot{Y}\} + [K]\{Y\} = 0$$

The kinetic energy of the structure in absolute and relative coordinates must be identical. Thus,

$$\tfrac{1}{2}\{\dot{Y}\}^T [M]\{\dot{Y}\} = \tfrac{1}{2}\{\dot{X}\}^T[m]\{\dot{X}\}$$

where $[m]$ is the mass matrix in relative coordinates. Applying the transformation equation $\{Y\} = [T]\{X\}$ the following is obtained.

$$\tfrac{1}{2}\{\dot{X}\}^T [T]^T [M][T]\{\dot{X}\} = \tfrac{1}{2}\{\dot{X}\}^T [m]\{\dot{X}\}$$

Thus,

$$[m] = [T]^T [M][T]$$

The relative stiffness matrix $[K']$ is defined as follows:

$$[K'] = \left[\begin{array}{c|c} k & 0 \\ \hline 0 & 0 \end{array}\right]$$

4.0 Description of Analysis (Continued)

The matrix k is the relative stiffness matrix of all coordinates other than the ignorables. The partitioned zero elements correspond to the ignorable coordinates themselves. All coordinate motions are taken relative to the ignorables. An element of the stiffness matrix is defined as a force required to produce a unit displacement at the particular degree of freedom, all other motions held to zero. The ignorable coordinates can move while all other motions relative to it are held to zero, through rigid body motion. The force required to produce a unit of rigid body motion in a free-free structure must be zero. Since the displacement of these coordinates does not contribute to the internal potential energy, the terminology, ignorable, is justified.

The equations of motion in relative coördinates are then written in the following format:

$$\left[m\right]\left\{\ddot{X}\right\} + \left[K'\right]\left\{X\right\} = 0$$

Partitioning the relative from the ignorable coordinates the following is obtained:

$$\left[\begin{array}{c|c} \alpha & \beta \\ \hline \gamma & \delta \end{array}\right]\left\{\begin{array}{c} \ddot{X}_R \\ \hline \ddot{X}_I \end{array}\right\} + \left[\begin{array}{c|c} k & 0 \\ \hline 0 & 0 \end{array}\right]\left\{\begin{array}{c} X_R \\ \hline X_I \end{array}\right\} = 0$$

Thus

$$\left[\alpha\right]\left\{\ddot{X}_R\right\} + \left[\beta\right]\left\{\ddot{X}_I\right\} + \left[k\right]\left\{X_R\right\} = 0$$

$$\left[\gamma\right]\left\{\ddot{X}_R\right\} + \left[\delta\right]\left\{\ddot{X}_I\right\} = 0$$

From above.

$$\left[\alpha\right]\left\{\ddot{X}_r\right\} - \left[\beta\right]\left[\delta\right]^{-1}\left[\gamma\right]\left\{\ddot{X}_R\right\} + \left[k\right]\left\{X_R\right\} = 0$$

and

$$\left[k\right]^{-1}\left[\alpha - \beta\delta^{-1}\gamma\right]\left\{\ddot{X}_R\right\} + \left\{X_R\right\} = 0$$

4.0 Description of Analysis (Continued)

become the final equations from which the modal frequencies and mode shapes in relative coordinates are determined. It should be noted that the matrix $\left[k\right]^{-1}$ is the relative influence coefficient matrix.

Having determined the modal vectors $\left\{X_R^i\right\}$, the corresponding motions at the ignorable coordinates are determined by the relation

$$\left\{\ddot{X}_I\right\} = -\left[\delta\right]^{-1}\left[\gamma\right]\left\{\ddot{X}_R\right\}$$

The complete modal vector in relative coordinates is then

$$\left\{X^i\right\} = \left\{\begin{array}{c} X_R^i \\ \hline X_I^i \end{array}\right\}.$$

Where i refers to the i^{th} natural mode of vibration.

The modal vector in absolute coordinates is determined by the transformation equations

$$\left\{Y^i\right\} = \left[T\right]\left\{X^i\right\}$$

Therefore the only input data required to the free vibration analysis are:

1. The absolute Mass Matrix $\left[M\right]$
2. The relative influence coefficient matrix $\left[k\right]^{-1}$ and
3. The coordinate transformation matrix $\left[T\right]$

5.0 TEST APPARATUS AND INSTRUMENTATION

5.1 Apparatus

The ground test facility employed to establish the dynamic characteristics of the test vehicle consists of a bungee suspension system to simulate a free-free condition, a rotorhead mounted unidirectional shaker and the Sikorsky shake test instrumentation console (Figures 3 and 4). Hydraulic power supplies are provided to operate the shaker and to raise the aircraft from its cradle to the test position.

The flexibility of the bungee suspension system, (Figure 3) is such that all rigid body vehicle modes are below 1HZ and are therefore isolated from excitations in the frequency range of interest.

The shaker consists of two counter rotating eccentric masses with adjustable unbalance which provide a unidirectional sinusoidal excitation whose magnitude is proportional to the square of the rotational speed. The shaker can produce a maximum excitation force of 2000 lbs. up to 40 HZ. The shaker is driven by a commercial pump with a manually operated bypass valve to adjust speed.

A steel shaker plate attached to the top of the transmission housing (Figure 3) serves as a mounting surface for the shaker, provides attachment points for the bungee suspension system and is used to mount ballast to vary the mass and moment of inertia of the transmission/simulated rotorhead.

5.2 Instrumentation

Instrumentation consists of 14 fixed and 10 roving accelerometers. The fixed accelerometer locations and their orientations are:

LOCATION	DIRECTION
Pilot	Vertical
Copilot	Vertical
Cockpit	Lateral
Shaker	Direction of Shaker Force
Shaker Mounting Plate	Lateral
Shaker Mounting Plate	Longitudinal
FS 322 Top Center Line	Lateral
FS 322 Top Center Line	Vertical
FS 342 Right Side XSSN	Vertical
FS 342 Left Side XSSN	Vertical
FS 362 Top Center Line	Lateral
FS 362 Top Center Line	Vertical
FS 744 Tail Fold Hinge	Vertical
FS 744 Tail Fold Hinge	Lateral

5.2 Instrumentation (Continued)

All accelerometer signals and the reference 1/Rev. shaker contactor signal are transmitted to the Sikorsky shake test instrumentation console. The signals are processed automatically by the console resulting in a calculation of the real and imaginary part of the accelerations. The accelerations are then normalized to the magnitude of the shaker force per shaft at the particular frequency. As frequency is varied, the resulting response of each accelerometer is recorded on a XYY' plotter, (Figure 4) as g's/1000 lbs. versus frequency.

A fuselage mode can be identified by a peak in the imaginary response and a simultaneous zero crossing of the real response (Figure 5) Once a mode is located, all imaginary responses at this frequency can be recorded to define the mode shape.

6.0 CORRELATION STUDY - PHASE I

6.1 Testing

6.1.1 Configuration

The test article is a stripped down version of the CH-53A. Appendages removed include:

- Tail pylon aft of the fold hinge
- Horizontal stabilizer
- Tail rotor
- Tail rotor and intermediate gear box
- Non-structural cargo ramp door
- Fuel and landing gear sponsons
- Main and nose landing gear
- Electrical and hydraulic systems
- Engines
- Main transmission gears and rotor shaft

Photographs of the test article are shown in Figures 6 through 9.

Hardware required for the shake test including the shaker mounting plate and unidirectional hydraulic shaker described in Section 5.0 are installed.

6.1.2 Test Results

Shake tests are performed in accordance with the procedure described in Section 5, Test Facilities and Procedures. The following modes are identified.

Mode	Frequency (CPM)
1st Lateral Bending	910
1st Vertical Bending	1155
Transmission Pitch	1490
2nd Vertical Bending	1950
Transmission Roll	2000
Transmission Vertical	2150
Torsion	2300

6.2 Vehicle Basic Data

6.2.1 Structural Arrangement

The vehicle utilized for this test and correlation study is the CH-53A Tie Down Aircraft, vehicle designation number 613. An overall general arrangement of the structure is illustrated in Figure 10. For the purpose of this study, all appendages are removed. These include the nose gear, main landing gear, main landing gear sponsons, fuel sponsons, tail pylon aft of the fold hinge, tail rotor and associated gear boxes, horizontal stabilizer and all remaining electrical and hydraulic systems. All gears are removed from the main transmission housing, and only the housing itself is retained for the test configuration. The remaining aluminum semi-monocoque structure consists of five modules: the cockpit from F.S. 100-162 (Figure 11), the forward cabin F.S. 162-322 (Figure 12), transmission support section F.S. 322-442 (Figure 13), the aft cabin F.S. 442-522 (Figure 14) and the ramp area F.S. 522-746 (Figure 15).

The primary structure of the cockpit is provided by two full depth beams at B.L. 16.44 on the right and left sides of the fuselage. The upper flanges of the fore and aft vertical beams are stabilized by a cockpit floor running aft to the cabin bulkhead at F.S. 162.

The forward cabin section, F.S. 162-322 contains a personnel and rescue door on the right side F.S. 182-222, a 24-inch by 32-inch escape hatch on the left side F.S. 197-222 and under normal operating conditions supports the engines and engine driven gear boxes. The transmission is supported by two main frames at F.S. 322 and 362 which are connected by two longitudinal beams located on the left and right side of the structure at B.L. 20. There are six transmission support points, two at each of the main frames at F.S. 322 and 362 and one on each of the longitudinal beams at F.S. 342. Two major frames are contained in the aft cabin, F.S. 442-522, the landing gear frame, F.S. 442 and the aft cabin frame at F.S. 522. The aft cabin fuselage frame at F.S. 522 serves as a redistribution and ramp support structure.

The aft section structure extends from F.S. 522 to the tail pylon fold hinge at F.S. 746. It is basically an inverted channel section tapering from F.S. 522-689.5. The open section of the channel is filled by the cargo and personnel ramp. This ramp is removed for this program due to its nonstructural nature. Aft of F.S. 612 a complete torque box exsits back to the pylon fold hinge at F.S. 746. A heavy closure member along each edge of the cargo door serves as a hardpoint for the door seal and the major axial members.

6.2.2 Structural Properties

6.2.2.1 Stringers and Panels

The cabin geometry from fuselage stations 162 through station 522 is of constant cross section. The primary axial structure consists of 62 stringers spaced about the circumference. The stringer and panel designation numbers and a tabulation of all stringer locations, stringer areas and panel gages are defined in Figure 16 and Tables 1 through 3.

The ramp area from F.S. 522-612 initially contains 46 stringers at F.S. 522 and tapers to a section containing 34 stringers at F.S. 612. The stringer and panel number designation for this section of fuselage is illustrated in Figure 17. The actual stringer locations, stringer areas and panel gages are presented in Tables 4. through 8. Included in these tables are the fuselage station at which the axial members end due to taper in the structure.

The tail cone F.S. 612-746 contains 34 stringers at F.S. 612 and tapers to a 24 stringer closed section at F.S. 746. The stringer designations are defined in Figure 18 Where a stringer is not effective due to a local cut out or the stringer has ended, a zero is indicated for the appropriate area in the tabulation of properties, Tables 9 through 14. Thus at F.S. 612 aft, 34 total stringers are indicated although areas for only 31 are defined. Similarly at F.S. 746 areas are defined for only 24 of the 34 indicated stringers.

6.2.2.2 Frame Properties F.S. 262-442

A complete compilation of frame properties is presented for the cabin from fuselage stations 262-442. The frame element designation numbers are defined in Figure 16. The overall frame properties are generated utilizing a FORTRAN computer program ICALC. This program computes the section area, neutral axis location, and moment of inertia of the frame section, given dimensions and locations of the individual elements which comprise the frame section. Representative sections normal to the skin line are examined beginning at B.L. 0. at the top of the frame and proceeding around the frame to each stringer location. Assumptions utilized in calculating frame properties are:

(1) In web and flange areas where large holes exist, the section is taken through the hole.
(2) Local increases in flange width for stringer attachment, small fittings and clips for longitudinal members are not included.
(3) Web stiffners are not included.
(4) Straps and attachments running several inches about the circumference are included.

6.2.2.2 Frame Properties F.S. 262-442 (Continued)

(5) Materials from the outer cap of the frame to the skin line on floating frames are neglected.
(6) No skin is considered to be contributing to the frame stiffness.
(7) All material at major splices is considered effective.
(8) The frames are assumed to be capable of carrying shear, axial load and bending in the plane of the frame only.

A tabulation of all frame and beam properties from F.S. 262-442 is presented in Tables 15 through 16. The frame properties utilized in the finite element modeling of the aft fuselage and ramp area from F.S. 442-612 are presented in section 6.6.

6.2.3 Mass Properties

The panel point lumped mass properties of the structure described in Section 6.2.1 are presented in Table 17. The data represents the total structural mass at each designated panel point and the mass moments of inertia about each of the three principal axes of rotation at the specified location.

The only appendages on the structure consist of the transmission housing, shaker adapter plate and 2000 lb. capacity hydraulic unidirectional shaker. The mass properties of these components along with individual center of gravity locations are presented in Table 18.

To provide the more detailed mass data required for dynamic analyses utilizing a finite element (flexible frame) representation of fuselage sections, a detailed distribution of masses at frame stations has also been generated. This data is presented in Figure 19.

6.3 Six Bay Original Degree of Freedom Model

6.3.1 Dynamic Model

The initial model considers the cockpit and forward fuselage up to F.S. 282 as a simple beam in which frame deformation is neglected (rigid frames). The transmission section from F.S. 282-402 is modeled as a detailed flexible frame structure utilizing the PPFRAN program. The aft cabin and ramp area from F.S. 402-746 is also considered as a beam. The frames at fuselage stations 282 and 402 are rigidized so that the motions of these end frames can be represented by the six degrees of freedom at a single point in the plane of each frame. The beam models of the forward and aft fuselage are married to the finite element model of the transmission section at these points through compatibility of deflections and rotations.

6.3.1.1 Dynamic Degrees of Freedom

The dynamic degrees of freedom for the nose and tail beams and the ignorable coordinates (Section 4) are illustrated in Figure 20. The cantilever points shown in this figure are relative support points utilized in the determination of structural influence coefficients. As described in Section 4, this method of analysis is utilized in order to minimize the coupling between influence coefficients and also to provide the capability of easily modifying the structural characteristics of any substructure without recalculating the total influence coefficient matrix.

The typical assignment of dynamic degrees of freedom to individual frames from F.S. 302 through and including F.S. 382 is illustrated in Figure 21. A typical frame assignment is 24 degrees of freedom. A single lateral degree of freedom is used on the top and bottom of each frame and a single vertical degree of freedom is utilized on each side of a frame. The frames are quite rigid in their planes as far as axial load is concerned and thus it is assumed that all masses on the top of a frame will move laterally simultaneously. Similarly it is assumed that all masses on the sides of a frame will move in the vertical direction simultaneously. It should be noted that no degrees of freedom are assigned to the top of the frames at F.S. 322, 342 and 362. The transmission, considered rigid in comparison to the fuselage structure, is mounted on these frames and thus all masses on the tops of these frames lumped at transmission tiedown points are constrained to move with the transmission. Thus the masses normally assigned to these points are transferred to the ignorable coordinates (Figure 20), which represent the motion of the center of the base of the transmission at W.L. 191. In order to further conserve dynamic degrees of freedom, the mass and moments of inertia of the transmission housing, shaker plate and shaker are also transferred to the ignorable coordinates through a rigid body transformation. The numbering and locations of all frame degrees of freedom are defined in Figure 22.

A total of 198 dynamic degrees of freedom are selected, 102 on flexible frames and the remaining 96 distributed among beam degrees of freedom and the ignorable coordinates. A complete list of the magnitude of masses for linear degrees of freedom and moments of inertia for rotational degrees of freedom is provided in the Mass Matrix of Table 19.

6.3.1.2 Structural Modeling

6.3.1.2.1 Beam Model

The total section beam bending properties and neutral axis locations for the nose beams from F.S. 162-282 and the tail beams from F.S. 402-744 are calculated utilizing the Sikorsky Shear and Bending Analysis Program (Y 019). All fuselage skin is assumed to be fully effective in carrying compressive loads as well as tensile loads due to the absence of steady

6.3.1.2.1 Beam Model (Continued)

applied loads of magnitudes sufficient to produce compression buckling. The program automatically accounts for shear lag distribution and the resulting effect on the axial load carrying effectiveness of stringers in the vicinity of cut-outs. The bending properties of the cockpit are determined by a manual analysis due to the complexity of the structure.

Torsional constants for all beam sections except the cockpit forward of F.S. 162 and the open ramp area between F.S. 522 and 612 are determined using standard strength of material theory for closed thin wall sections. The equation for the unit torsional displacement of a beam of this type is:

$$\theta = \frac{T \oint \frac{ds}{t}}{4A_i{}^2G} \qquad \text{Equation 1 (Reference 3)}$$

where A_i = the area swept by a radius from the shear center to the circumference as it rotates 360° (the enclosed area of the section)

t = the skin thickness

ds = an incremental length on the circumference

and G = is the shear modulus of elasticity.

The value of A_i for each closed thin wall beam section is developed directly by the Sikorsky Shear and Bending Analysis (Y 019). However a number of window and door cutouts exists which must be accounted for in determining the appropriate shear constants. Since these cutouts are not extensive in nature, the torsional stress distribution cannot completely change from that of a closed to a completely open section over the length of these cutouts. In order to properly account for the effect of these cutouts a finite element analysis is performed on a single cell semi-moncoque structure with representative dimensions and gages in which cutouts of varying size as a percentage of the circumference are considered. The sample structure is a three bay circular structure consisting of 16 stringers and with a nominal skin gage of .032 in. The torsional rotation across the bay in which the cutout exists is determined from the finite element analysis and then substituted in equation 1.

$$\theta_{\text{finite element}} = \frac{TL \left[\oint \frac{ds}{t} + \frac{\ell c}{t_{eff}}\right]}{4A_i{}^2\,G}$$

where ℓc = circumferential length of the cutout

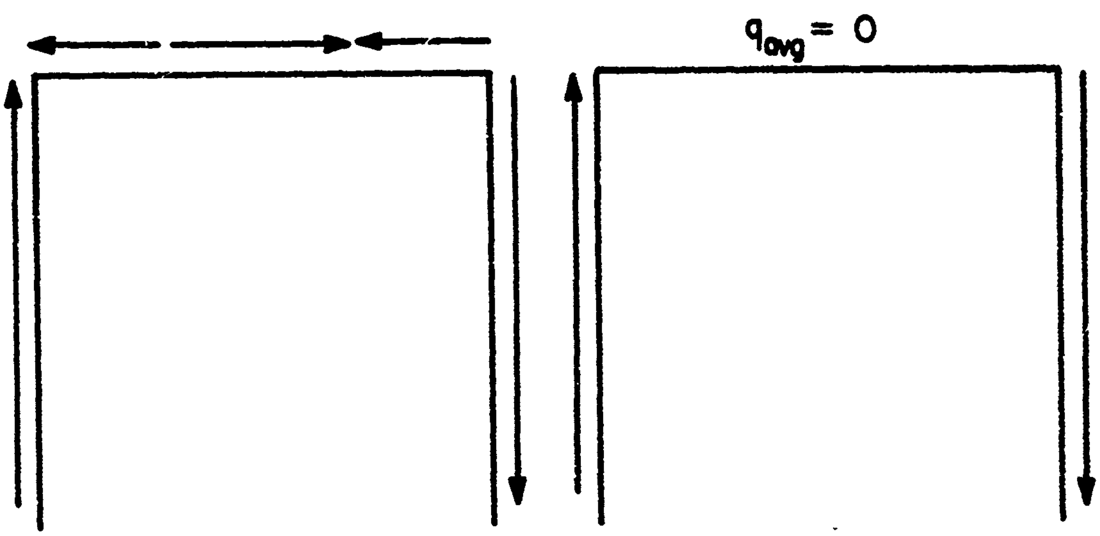
t_{eff} = effective skin gage

6.3.1.2.1 Beam Model (Continued)

The results of this analysis are plotted in Figure 23. Also indicated on this figure are typical cutouts for a window, door and heater encountered on the test aircraft.

A summary of the beam section bending and torsional properties from F.S. 162 to 744 are presented in Table 20. As seen the beam properties of the cockpit and torsional properties of the ramp area are not presented in this table. The development of these properties is discussed below.

The ramp area from fuselage stations 522-162 is an inverted channel section which tapers in depth from F.S. 522 to F.S. 612 (Figure 15). As stated above the torsional characteristics of the structure forward and aft of this area are established by applying equation 1. At F.S. 522 it is assumed that warping of plane surfaces produced by torsional loading is completely restrained. It is also assumed that warping of plane surfaces due to torsional loading is completely unrestrained at F.S. 612. In accordance with Timoshenko (Reference 3) the torsion at the assumed cantilever end, F.S. 522, is reacted by differential bending of the flanges as shown below.



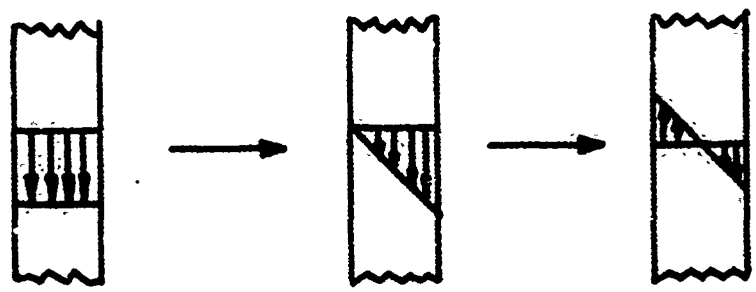
Actual
Shear Distribution
Cantilever End of Channel
Under Torsion

Assumed
Shear Distribution
Based Upon Airframe
Structures Assumptions

Shear Distribution, Cantilever
End of Channel Under
Pure Torsion

6.3.1.2.1 Beam Model (Continued)

As we proceed towards the assumed unrestrained end at F.S. 612 the shear distribution changes in increments until it takes on the characteristics of pure torsion of an open thin wall section with free ends.



Fixed End F.S. 522 | Mid Span | Free End F.S. 612

Shear Distribution in Flange of Channel Section under Torsion

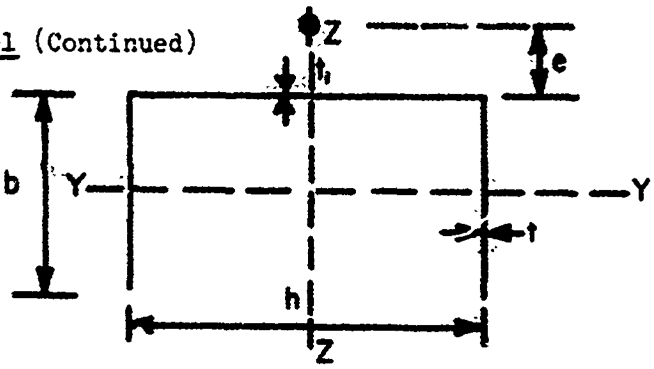
From Timoshenko (Reference 3) the rotation at any distance x from the fixed end due to a torque applied at the free end is given by Equation 2.

$$\theta(x) = \frac{T}{CG}\left[x + \frac{a \sinh \frac{\ell - x}{a}}{\cosh \frac{\ell}{a}} - a \tanh\left(\frac{\ell}{a}\right)\right] \quad \text{Equation 2}$$

The rotation at the free end is defined in accordance with Equation 3.

$$(\theta) = \frac{\ell T}{CG}\left[1 - \frac{a}{\ell}\tanh\frac{\ell}{a}\right] \quad \text{Equation 3}$$

6.3.1.2.1 Beam Model (Continued)



Channel Section Under Torsion

The definition of symbols utilized in Equation 2 and 3 are.

$$a^2 = \frac{Dh^2}{2CG}\left(1 + \frac{t_1 h_3}{4I_z}\right)$$

D = EI_y of each flange

I_z = Moment of inertia of total section about z axis

C = $1/3\ b_i\ t_i^3$

ℓ = length of beam

The shear center location is given by

e = $b_2h_2t/4I_z$

Utilizing the basic structural data of Tables 4 through 8 average values of all critical parameters for the structure from F.S. 522-612 are determined. These are provided below.

Average Parameters for Ramp Area Torsion Properties

e avg	9.57 in.
h avg	90.425 in.
b avg	63.363 in.
t_1 avg	.028? in.
t avg	.025 in.
I_z avg	22122. in.^{4}
C avg	1420.14×10^{-6}
I_y avg	1886.36 in.^{4}

6.3.1.2.1 Beam Model (Continued)

Substituting these parameters into Equations (2) and (3) results in the following relative rotations due to a torque of 10^6 in.-lbs. applied at F.S. 612.

$$\theta 612/522 = .002545 \text{ radians}$$

$$\theta 567/522 = .000795 \text{ radians}$$

$$\theta 612/567 = .00175 \text{ radians}$$

These are the values of the torsional influence coefficients of the ramp from F.S. 522-612 utilized in performing the dynamic analysis of this six bay model.

The torsional properties of the cockpit from fuselage station 108 to 162 are determined using the same method as applied to the ramp area. The cockpit is assumed to be cantilevered at F.S. 162 with the free end at F.S. 108. The primary structure consists of the floor and the two main longitudinal beams forming a channel. (Reference Section 6.2.1). Average properties for this section of fuselage are defined at F.S. 113. These are defined below.

Average Parameters for Cockpit Torsional Properties

h avg	22.88 in.
C avg	.0111
D avg	804.74 x 10^7
*I_z avg	2984.72 in.^{4}
t_i avg	.036 in.
b avg	34 in.
t avg	.0685 in.
e	7.174 in.
I_y avg (flanges)	804.74 in.^{4}

* Only the keel beams and floor web are considered in structure reacting torsion.

Substituting the appropriate values into Equations (2) and (3) results in a rotation of the free end at F.S. 108 relative to the fixed end at F.S. 162 due to a torque of 10^6 in.-lbs. of

$$\theta 108/162 = .0109 \text{ radians}$$

6.3.1.2.1 Beam Model (Continued)

The total section bending properties at F.S. 113 are also determined. In determining the bending properties additional axial load carrying members beyond the material assumed to be reacting torsion is considered. The resulting beam bending properties are:

$I_z = 14524$ in.^{4}

$I_y = 3004$ in.^{4}

6.3.1.2.2 Flexible Frame Model

Two finite element flexible frame models are considered for the region between F.S. 282 and 402. A thirty stringer model (Figure 24) and a sixty stringer model (Figure 25). These schematics are developed by the PPFRAN computer program and are used for input error checks. The basic stringer skin and frame properties of the fuselage are presented in Section 6.2. The input to the PPFRAN program requires that the axial load carrying capability of the skin be lumped at the stringer locations. The location and properties of the combined stringer/skin axial areas for both the 30 and 60 stringer models are presented in Table 21 and 22. In addition the averaged frame properties for the 30 stringer model are presented in Table 23. The frame properties are the average values between stringer locations. The finite element assumption for beam elements in the PPFRAN program requires that members possess constant properties between joints. The typical location of stringer, panel and frame elements in the 30 stringer model is illustrated in Figure 26.

6.3.2 Results and Correlation

As described in Section 6.1, seven modes of vibration are identified by the shake test. These are:

Mode	Test Frequency
1st Lateral Bending	910
1st Vertical Bending	1155
Transmission Pitch	1490
2nd Vertical Bending	1950
Transmission Roll	2000
Transmission Vertical	2150
Torsion	2300

6.3.2 Results and Correlation (Continued)

The mode shapes corresponding to these frequencies are illustrated in Figures 27 through 33. The results of the six bay thirty stringer analysis and the six bay sixty stringer analysis are virtually identical. These mode shapes and frequencies are also presented in Figures 27 through 33. A complete discussion of the correlation between test and analysis follows.

First Lateral Bending Mode

The test frequency is 910 cpm. Analysis predicts the mode at 1440 cpm, which is 50% too stiff. Initial examination of the analytical mode shape is limited to the average mid-height lateral response (Figure 27) due to its consistency with the beam modeling utilized in the nose and tail. The tail to nose displacement ratio in test is 1.5 as compared to 1.7 obtained in analysis. A comparison of node locations indicates those in test occurring at F.S. 270 and 500 while analysis predicts the nodes at F.S. 250 and 530. The dilemma as to the wide discrepancy in frequencies is answered by examining the lateral motion on the top and bottom of the fuselage in analysis as compared to test (Figure 27). The test data indicates a large amount of relative shear occurring between the top and bottom of the fuselage beyond F.S. 300. This characteristic appears to be controlled by the large cut-out in the ramp area. The analysis cannot predict this response due to the beam modeling utilized beyond F.S. 402. Therefore it is concluded that an extension of the flexible frame model into the ramp area is required in order to accurately predict this mode.

First Vertical Bending Mode

Excellent correlation is achieved between the analytically predicted mode at 1241 cpm and the test mode at 1150 cpm (Figure 28). Shape prediction is also excellent with amplitudes comparing within 10% and nodes predicted within 10 inches of those obtained during the tests.

Transmission Pitch Mode

Shake tests identify this mode at 1490 cpm and analysis predicts the node at 1758 cpm (Figure 29). Node locations are in good agreement and the absence of any aft fuselage motion is accurately predicted. It is considered that a major reason for the higher predicted natural frequency is the proximity of the "rigid" end frames at F.S. 282 and 402 to the frames which exhibit the greatest amount of distortion in this mode. It should be noted that the floor at WL 97 exhibited negligible vertical motion in this mode. It is concluded that analysis considering nine bays in the region of the transmission area F.S. 262-442 may provide improved correlation of this mode.

Second Vertical Bending Mode

The frequency correlation of this mode is quite poor. The test value is 1950 cpm while analysis predicts the mode at 2573 cpm (Figure 30). The tail to nose displacement ratio exhibits a 25 percent variance, test indicating a ratio of 4.4 to 1.0 while analysis predicts 5.5 to 1.0. Node locations are not predicted as well as the first vertical bending mode with a variance of up to 100 inches. As is the case with the first lateral bending mode, the analytical prediction of this mode is strongly controlled by modeling of the ramp area. Again it is concluded that a flexible frame model extending into the ramp area may serve to improve the correlation.

Transmission Roll Mode

A 45 percent difference exists between the test natural frequency of 2000 cpm and the predicted natural frequency of 2894 cpm (Figure 31). Torsional nodes at F.S. 200 and 440 compare favorably to the predicted however differences in location of up to 130 inches are found. The correlation again is considered poor and is attributed to lack of detail in the modeling of the ramp area.

Transmission Vertical Mode

Although this mode is identified as the transmission vertical mode its character appears to be controlled by the ramp area. This mode is not predicted analytically (Figure 32), due to the absence of finite element modeling in this portion of the fuselage.

Torsion Mode

The correlation of frequency, 2300 cpm in test as compared to 2445 cpm through analysis (Figure 33) is good. However, the comparison of mode shapes indicates that the frequency comparison may be fortuitious. The torsion node is in error by 140 inches while lateral response comparisions are poor. The lack of correlation is again attributed to the absence of a finite element model in the ramp area

6.4 Six Bay Reduced Degrees of Freedom Model

6.4.1 Dynamic Model

As stated in Section 4 the Sikorsky free vibration analysis is limited to 200 dynamic degrees of freedom. In order to extend the analysis to include a finite element description of the structure in the aft fuselage and ramp area, the number of dynamic degrees of freedom assigned to each flexible frame must be reduced in order to remain within the program's limits. Prior to extending the flexible frame modeling of the structure, a sensitivity study is performed on the six bay 30 stringer model (Section 6.3) to determine the effect of reducing dynamic degrees of freedom assigned to individual frames on the degree of correlation.

6.4.1.1 Dynamic Degrees of Freedom

The selected degrees of freedom for the six bay reduced degree of freedom model are illustrated in Figures 34 and 35 . The dynamic degrees of freedom assigned to each typical frame are reduced from 24 to 16. The locations of frame degrees of freedom are illustrated in Figure 36. The mass matrix corresponding to this dynamic model is presented n Table 24.

6.4.2 Results and Correlation

The predicted natural frequencies and mode shapes obtained from the reduced degree of freedom model are identical to those obtained from the original model. It is therefore concluded that the frame degree of freedom assignment of Figure 36 is adequate for dynamic modeling.

6.5 Nine Bay Analysis

6.5.1 Dynamic Model

As a result of the 17 percent difference between the analytical frequency obtained for the transmission pitch mode in the six bay analysis, and that obtained in test, the model was extended in the region of the transmission area. In the discussion of Section 6.3 it is noted that considerable frame deformation exists in this mode in the frames adjacent to F.S. 282 and F.S. 420 which are assumed to be rigid. Therefore, the finite element model of the transmission area is extended one bay forward to F.S. 262 and two bays aft of F.S. 442, resulting in the subject nine bay flexible frame model. The frames at F.S. 262 and 442 are assumed to be rigid in this analysis. A schematic of the flexible frame portion of the structure developed from the input data to the PPFRAN program is illustrated in Figure 37.

6.5.1.1 Dynamic Degrees of Freedom

The assignment of dynamic degrees of freedom for this model is presented in Figures 38 and 39. The corresponding mass matrix is defined by Table 25.

During the course of this analysis an additional sensitivity study was performed in which the stiffness of the structure in the cockpit was varied by 20 percent.

6.5.2 Results and Correlation

The resulting mode shapes are found to be essentially identical to those obtained from the six bay analysis. Further, little change in predicated frequency is obtained as seen below.

	FREQUENCY (CPM)		
MODE	6 BAY ANALYSIS	9 BAY SOFT NOSE	9 BAY STIFF NOSE
1st Lateral	1440	1466	1473
1st Vertical	1[illegible]41	1282	1284
XSSN Pitch	1758	1710	1715
2nd Vertical	2577	2390	2390
XSSN Roll	2894	2870	2870
XSSN Vertical	----	----	
Torsion	2445	2428	2428

As a result of this analysis the following conclusions are reached.

(1) The dynamic characteristics of helicopter structures of the CH-53 type are insensitive to modeling assumptions applied to the cockpit.
(2) For a vehicle without a cargo ramp, the length of the flexible frame modeling of the structure in the transmission area should be determined as follows:

The flexible frame model should extend about 1.5 times the length of the transmission base in the forward and aft directions from the corresponding transmission supports.

A more extensive analysis will produce no improvement in prediction of transmission modes.

6.6 Eighteen Bay Model

6.6.1 Dynamic Model

The correlation of Section 6.3 indicates that an extension of the finite element model to include the aft fuselage is required to accurately predict the modes controlled by this portion of the fuselage. The flexible frame finite element model utilized spans fuselage from F.S. 262 - F.S. 632. However, due to the limitations of the PPFRAN program (Section 4) this section of the model is divided into two major substructures; a nine bay model from F.S. 262-442 which is identical to that utilized in the analysis of Section 6.5 and a second nine bay structure from F.S. 442-632. As is the case in the analysis of Section 6.5, the structure from F.S. 262-442 is supported at the main transmission mounting points The substructure module from F.S. 442-632 is cantilevered at F.S. 442. Both the frames at F.S. 442 and 632 are assumed rigid.

6.6.1.1 Dynamic Degrees of Freedom

The dynamic model applied in this analysis is illustrated in Figures 40 and 41. Due to the limitation of 200 dynamic degrees of freedom, frame degree of freedom assignments in the fuselage beyond F.S. 402 are limited to F.S. 482, 522 and 567. However, the flexibility of this structure is defined by the complete structure. The definition of the frame dynamic degree of freedom locations is presented in Figure 36. The corresponding mass matrix is provided in Table 26.

6.6.1.2 Structural Modeling

All structural data for the nose beam forward of F.S. 262, the tail beam aft of F.S. 632 and the forward finite element model, F.S. 262-442, are defined in Sections 6.3 and 6.4.

A schematic of the nine bay finite element model utilized from F.S. 442-632 is presented in Figure 42. The stringer locations at F.S. 442 correspond to those in the nine bay model of the structure from F.S. 262-442 (Figure 37). All dashed elements represent dummy members of zero area which are required by the Pre-FRAN program, due to its inherent design for application to single celled closed sections. These dummy elements are removed automatically prior to analysis by the main core of the PPFRAN program, namely FRAN. A development of this structural model is shown in Figure 43 in which all joints are identified in accordance with the format of the Pre-FRAN program. Even units correspond to the bay, odd unit designations define frames. It should be noted that each bay contains the same number of stringers, even though stringers actually terminate in the ramp due to taper. This requirement of equal stringers in each bay is a fixed logic in Pre-FRAN. Stringer areas are adjusted accordingly in the modeling. A tabulation of all member properties skin gages and joint locations for this model is presented in Table 27.

As described in Section 4, the Pre-FRAN program transforms all skin panels into pairs of rod diagonals. In addition it transforms the resulting member and joint data into the format required for input to the FRAN program. The Pre-FRAN program is not designed to accommodate a number of characteristics contained in this structure at F.S. 612 and 632 namely; a bulkhead at F.S. 612 and the fact that the structure in this region is not actually a single closed cell but has a shear deck extending horizontally from stringer 6-26 and ears on each side of the fuselage from stringer 21-26 on the left side and 6-11 on the right side. To accommodate these features the basic structure defined by Figure 42 is transformed by Pre-FRAN. Punched cards are obtained and members are added and deleted manually as required. A description of this procedure follows.

6.6.1.2 Structural Modeling (Continued)

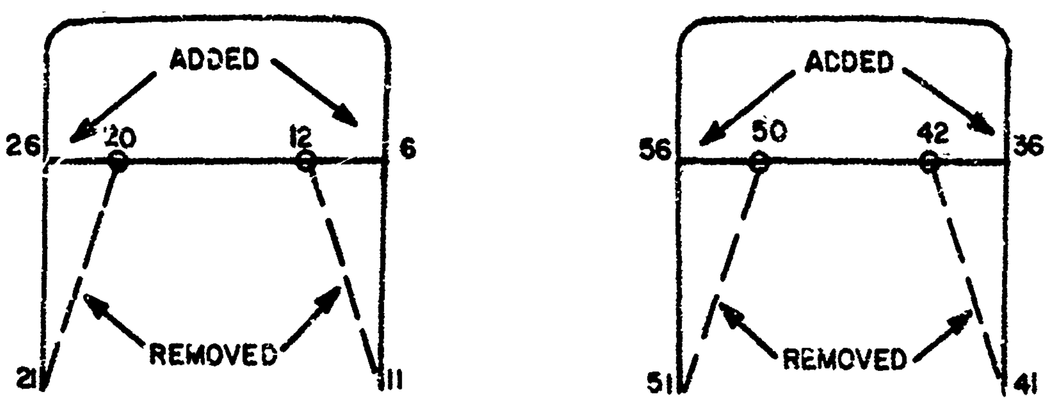
Members Removed

20 - 21, 11 - 12
50 - 51, 41 - 42

Panels Removed

20, 21, 50, 51
11, 12, 41, 42

Members Added	Area (In^2)
6 - 12	.256
20 - 26	.256
36 - 42	.168
50 - 56	.168



VIEW FORWARD

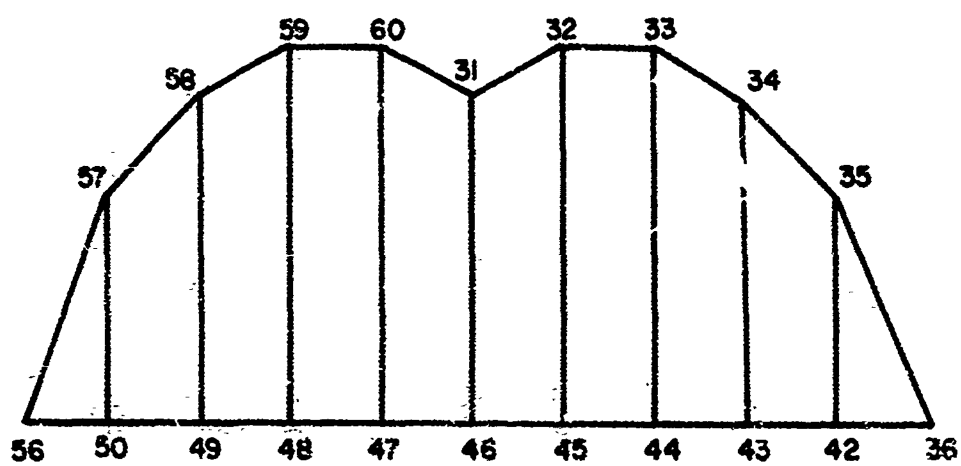
Manual Modeling F.S. 612 and 632

6.6.1.2 Structural Modeling (Continued)

In addition to adding the members described above, the appropriate rod elements to represent panels 20, 26, 50, 56 and 6, 12, 36, 42 are developed utilizing the panel transformation formulas of Section 4. The resulting areas of these equivalent rods for panels having a thickness of .048 inches are:

Member	Area (In^2)
12, 36	.389
6, 42	.389
20, 56	.390
26, 50	.390

The bulkhead at F.S. 612 is illustrated below.



VIEW FORWARD

Bulkhead at F.S. 612

6.6.1.2 Structural Modeling (Continued)

The thickness of all panels in this bulkhead is .025 inches. The properties of circumferential frame elements is defined in Table 27. The areas of vertical stiffeners are:

Member	Area (In^2)
50 - 57	.082
49 - 58	.071
48 - 59	.235
47 - 60	.0895
46 - 31	.044
45 - 32	.0895
44 - 33	.246
43 - 34	.071
42 - 35	.082

The panels are transformed utilized the equations described in Section 4. The resulting rod elements which replace the skin panels in the bulkhead at F.S. 612 are:

Member	Area (In^2)
31, 47	.137
31, 45	.137
46, 60	.137
32, 46	.137
48, 60	.236
32, 44	.236
47, 59	.236
33, 45	.236
48, 58	.180
33, 43	.180
48, 59	.180
39, 44	.180
49, 57	.145
34, 42	.145
50, 58	.148
35, 43	.148

6.6.2 Results and Correlation

The analytically predicted mode shapes and natural frequencies are compared to those generated from the test data in Figures 44 through 49. As expected, the extension of the finite element model into the cargo ramp area produced a significant improvement in correlation. A thorough evaluation of modes in which discrepancies between test and analysis still exist follows.

6.6.2 Results and Correlation (Continued)

First Lateral Bending Mode

A substantial improvement in both mode shape and frequency is achieved. However, the frequency remains 33 percent higher than the test value. It appears that the frequency of this bending mode is affected by the presence of the "rigid" frame at F.S. 442. Test indicates that the relative lateral shear between the top and bottom of the fuselage initiates forward of F.S. 442. However, due to the rigidity of this frame, the analysis only permits this same motion aft of F.S. 442. It is concluded that removal of this rigidity would lower the predicted frequency and improve the mode shape correlation by permitting increased relative lateral shear deformation in the aft fuselage. However, the structure analyzed tends to be overly sensitive to modeling assumptions such as this and correlation with a structure having a more realistic mass distribution would prove to be less sensitive.

Transmission Pitch Mode

The predicted frequency of the transmission pitch mode (Figure 46) is still too high. It is concluded that the absence of a realistic mass distribution has made the analysis overly sensitive to the beam modeling assumption in the forward fuselage. Test (Figure 46) indicates that only the top of the forward fuselage has substantial motion in this mode, rather than the entire forward fuselage as constrained by the beam model in the analysis. The accuracy of predicting this mode will improve if the full mass of the transmission were present to more closely simulate the actual aircraft, and reduce the sensitivity of this mode to local beam modeling assumptions. Extension of the flexible frame model through the cargo ramp does not affect this mode due to the lack of activity in the aft fuselage.

High Frequency Modes

The three high frequency modes, Transmission Vertical. Transmission Roll and Torsion (Figures 48, 49 and 50) are difficult to identify due to analytical coupling of overall fuselage modes with local frame modes. Initially the shapes could not be identified due to the predominance of local frame motions in the aft fuselage. The shapes are identified after washing out the large local frame motions and normalizing the remaining response to the largest residual motion. The coupling of fuselage and frame modes is produced by the combination of physically increasing the frequency of fuselage modes by the removal of all non-structural masses and mathematically reducing the frequency of frame modes by modeling the frames which are continuous mass system at discrete lumped mass points. This difficulty cannot arise in the actual fully assembled aircraft since the frequencies of fuselage modes of interest varying from 300-1500 cpm are well separated from local frame modes which are above 2000 cpm.

6.7 Phase I Summary, Conclusions and Recommendations

A summary of the various correlations performed during the Phase I effort is presented in Table 28. The criteria for establishing the level of mode shape correlation is:

E (Excellent) - Correct number of nodes, nodes within 20 inches of test location, modal amplitudes within 20 percent of test values.

G (Good) - Correct number of nodes, nodes within 20 inches of test location, modal amplitudes exceed ±20 percent of test values.

F (Fair) - Correct number of nodes, nodes greater than 20 inches away from test location, modal amplitudes exceed ±20 percent of test values.

P (Poor) - Incorrect number of nodes, nodes not located properly, modal amplitudes greater than ±20 percent of test values.

(a) The selection of static degrees of freedom in the flexible frame model can be based on a structural model which contains lumped stringers numbering one half the number of actual stringers.

(b) No more than sixteen dynamic degrees of freedom on each flexible frame are required for adequate dynamic modeling.

(c) The prediction of overall airframe modes is generally insensitive to modeling of the cockpit and forward fuselage structural stiffness.

(d) A flexible frame representation of the transmission support region extending about 1.5 transmission lengths forward and aft of the corresponding transmission supports is adequate for predicting the fuselage and a transmission modes of a vehicle without a rear cargo ramp.

(e) A vehicle with a rear cargo ramp requires a mathmetical model which includes a flexible frame representation spanning 1.5 transmission base lengths forward of the transmission supports through and including the rear cargo ramp.

(f) Utilization of an intermediate "rigid" end frame to couple two flexible frame substructures which comprise a total span exceeding nine bays results in an overly stiff model if one substructure contains a large cutout. In this event the structure should be modeled as a single entity.

(g) Overall correlation with the 18 bay flexible frame model in the frequency range of interest (< 2000 cpm) is extremely encouraging. Frequencies are within 2% - 30% of test values and mode shapes vary from good to excellent.

(h) The largest frequency difference of 30% in the first lateral mode is attributed to the intermediate "rigid" end frame at FS 442 in the 18 bay analysis. (See Conclusion f.)

(i) The transmission pitch mode, whose shape is excellent, is 13% too stiff due to the absence of transmission mass which is normally present. Test data indicated the only vertical motion in the forward cabin in this mode was on the top of the fuselage. In order for the top of the fuselage to move in a beam model the entire section must deform, resulting in an inherently stiffer model of this mode. The major portion of the kinetic and potential energy in this mode normally exists in the immediate area of the transmission. In the absence of the large transmission mass and resulting motions, the model becomes overly sensitive to the beam modeling assumption in the forward fuselage. Thus the model is overly sensitive to the beam model assumption used in the forward fuselage.

(j) The high frequency modes (above 2000 cpm) are difficult to identify due to coupling of overall fuselage modes with local frame modes. This difficulty was compounded in the present investigation because basic fuselage modes were raised (due to the stripped nature of the vehicle) while local frame modes were lowered (due to lumped mass modeling of each frame). Tests of more complete, representatively loaded fuselages would be expected to minimize this problem.

(k) It is recommended that further testing and correlation be performed following the addition of concentrated masses at the nose, transmission and pylon fold hinge.

7.0 CORRELATION STUDY - PHASE II

7.1 Testing

7.1.1 Configuration

The starting point for this investigation is the test vehicle used in the Phase I investigation with the addition of ballast to provide a more realistic representation of a helicopter mass distribution.

At the transmission mounting plate two lead blocks having a total weight of 4570 lbs. are placed transverse to the fore and aft line each 23.5 inches from the rotor shaft center and at W.L. 230 (Figure 51). The weights are selected so that the mass and pitching moment of inertia of the simulated transmission and rotor head approximate that of the actual CH-53A. At the tail, a weight of 1500 lbs. is hung with its center of gravity at F.S. 758. This weight simulates that of the removed tail pylon, stabilizer and tail rotor. This installation is shown in Figure 52. At the nose a 3000 lb. block assembly is mounted on the nose gear trunnion fitting to balance the vehicle, Figure 53. The weights, inertias and locations of all mass appendages is tabulated in Table 29..

7.1.2 Test Results - Phase II

The shake test is performed in accordance with test procedures described in Section 5, Test Facilities and Procedures. The following modes are identified:

MODE	TEST FREQUENCY CPM
1st Vertical Bending	440
1st Lateral Bending	615
Transmission Pitch	740
Forward Cabin Lateral	840
Nose Block Lateral/Roll	930
Nose Block Vertical/Coupled Transmission Pitch	970
Forward Cabin/Nose Block Lateral	990
Nose Block Vertical	1050
Second Vertical Bending	1290
Torsion	1310

7.1.2 Test Results - Phase II (continued)

MODE	TEST FREQUENCY CPM
Transmission/Ramp Vertical Bending	1425
Ramp Vertical Bending	1630

Modes at frequencies beyond 1630 cpm have been deleted since they are beyond the frequency range of interest in helicopter structures.

7.1.3 Evaluation of Test Results

1st Vertical Bending - In the Phase II test mode, Figure 54, the increase in tail curvature is attributed to the 1500 lb. tail ballast block. In addition, the considerably larger response in the nose than was encountered in the Phase I test, Figure 28, is attributed to the 3000 lb. nose ballast block. The frequency has been reduced considerably so that the mode is now in the region where fuselage modes of this type are normally encountered.

1st Lateral Bending - The addition of ballast masses to represent the mass distribution of the actual vehicle has succeeded in reducing the lateral differential shear in the aft fuselage which had been encountered in Phase I and is identified as being the major cause of the lack of frequency correlation in this mode (Figures 27 and 55).

Transmission Pitch - The curvature in the transmission area in this mode, Figure 56, is much greater than encountered in the Phase I test due to the larger pitch moment of inertia of the ballasted transmission. In addition, the Phase II test mode exhibits considerable curvature and deformation in the nose, tail and ramp area which is not indicated in the Phase I test data. This indicates that the concentrated nose and tail ballast masses are playing a strong role in controlling the shape and frequency of this mode.

Ramp Controlled and Torsion - The ramp controlled modes and higher frequency torsion modes, Figures 62, 63, 64 and 65, are at frequencies which are approximately 70% of those obtained during Phase I which is nominally consistent with the 250% increase in vehicle gross weight.

7.1.3 Evaluation of Test Results (continued)

In addition to the modes described above, five additional modes are encountered, three lateral and two vertical, which appear to be strongly influenced by the existence of the 3000 lb. nose ballast block.

These are identified as:

Forward Cabin Lateral	(Figure 57)
Nose Block Lateral/Roll	(Figure 58)
Forward Cabin Lateral/Nose Block Lateral	(Figure 60)
Nose Block Vertical/Transmission Pitch	(Figure 59)
Nose Block Vertical	(Figure 61)

The addition of the nose and tail ballast has succeeded in bringing the fuselage modes into a frequency range more representive of that encountered in a fully assembled aircraft. However, it appears that some of the modes encountered are strongly controlled by the ballast and in fact, in the five cases cited above are actually local ballast modes. The modeling of the ballast in the dynamic analysis, particularly the nose block, must therefore be examined carefully at each step in the correlation study.

7.2 Eighteen Bay Rigid Ballast Model Correlation

7.2.1 Dynamic Model

To update the Phase I dynamic model for computer analysis, the mass matrix is modified to include the masses and inertias of the ballast identified in Table 29. Due to the large magnitude of the transmission ballast, large off-diagonal mass matrix elements result if the masses and inertias are transferred to and input at the ignorable coordinates. It has been established that the program does not function properly with large off-diagonal mass matrix elements in the presence of a non-diagonal transformation matrix. To eliminate this situation, a new set of degrees of freedom is established at the center of gravity of the simulated transmission and rotor. The total mass and inertia of the transmission is concentrated at these degrees of freedom.

7.2.1 Dynamic Model (continued)

Additional elements in the transformation matrix are calculated to couple the new dynamic degrees of freedom to the reference ignorable coordinates at F.S. 342, W.L. 191. All ballast masses are assumed rigidly connected to the fuselage structure; therefore, the influence coefficient matrix remains the same as for Phase I analysis.

The dynamic degrees of freedom used for this analytical model are shown in Figures 66 and 67. The corresponding mass matrix is listed in Table 30.

7.2.2 Results of Correlation, 18 Bay-Rigid Ballast Model

The modes obtained from this analysis are:

MODE	FREQUENCY (CPM)
1st Vertical Bending	482
1st Lateral Bending	713
Transmission Pitch	818
Second Lateral Bending	1105
Ramp Vertical	1394
Second Vertical	1523
Transmission Vertical	1563
Ramp Torsion	1601

The analysis was cut off at frequencies above 1600 cpm since this is beyond the normal range of interest in helicopter structures.

Examination of the mode shapes and frequencies indicated some large discrepencies when compared to the test data of Section 7.1.2, particularly in the frequency range below 1000 cpm. A severe discrepancy exists in the transmission pitch mode in that the large deformation in the nose, tail and ramp area seen in test are not predicted. In addition, none of the five local modes identified in test as lateral and vertical nose block modes are predicted by analysis.

These descrepancies raised a great deal of suspicion concerning the rigid modeling of the nose and tail ballast blocks. The actual installation is suspected of having significant flexibilities in their supports which would account for the existance of local modes and the descrepancies between test and analysis.

7.2.2 Results of Correlation, 18 Bay Rigid Ballast Model (continued)

In order to examine for and define this flexibility, the nose and tail blocks and the aircraft structure in the vicinity of the ballast supports was instrumented and accelerometer data was recorded in both the 0-1000 cpm range and at system resonant frequencies above 1000 cpm. It was determined that no relative motion between the ballast blocks and the fuselage existed at frequencies above 1000 cpm and thus the rigid block dynamic model is valid for correlation at these frequencies. However, considerable relative motion exists at frequencies below 1000 cpm particularly in the range 700-900 cpm where the local ballast block modes are identified.

7.2.3 Measurement of Ballast Block Relative Flexibility

This is accomplished by instrumenting both the blocks and the airframe structure with accelerometers in the direction desired and measuring the accelerations of the block and the airframe at or near the modes of interest. The mass and inertias of the ballast are known and the accelerations are measured. The mass and absolute acceleration is reduced to a force which produces the relative motion between the two instrumented parts. The relative displacement is calculated from the known frequency and relative accelerations. The following relations define acceleration as a function of displacement and frequency.

$$\ddot{X}_i = - \omega^2 X_i$$

$$\ddot{X}_j = - \omega^2 X_j$$

Where X_i and X_j are the absolute motions of the ballast and airframe support structure respectively.

The absolute force producing the relative motion is:

$$F = M\ddot{X}_i$$

The relative flexibility is then the relative deflection divided by the absolute force.

$$1/_k = \left(\frac{X_i - X_j}{F}\right)$$

This calculation of relative flexibility is consistent with the substructure analysis utilized through the analysis.

7.2.3 Measurement of Ballast Block Relative Flexibility (continued)

New absolute and relative degrees of freedom are assigned at the center of gravity of the nose and tail ballast block. The relative flexibilities computed from the shake test data are then the appropriate relative influence coefficients corresponding to the ballast and its support structure.

The method utilized substantiates not revising the analytical model for correlation of modes whose frequencies are above 1000 cpm. At these frequencies the relative motion between the ballast and its support is zero. Thus indicating an infinite relative flexibility.

As a result of this investigation it is determined that flexibility exists in the nose block and its supports in the vertical/pitch and the lateral/yaw/roll directions. The tail block exhibits relative flexibility in the vertical/pitch/longitudinal directions only.

7.2.4 Modifications to Mathematical Model

Nose Ballast Block

Tests indicate that the forward half of the ballast block is bending relative to the fuselage in the vertical/pitch direction. The aft half of the block is prevented from moving vertically relative to the fuselage by the pressurized hydraulic actuating strut (Figure 53). In addition, it is determined that relative motion of the entire block relative to the fuselage exists in the lateral/roll/yaw direction.

The relative influence coefficients of the forward half of the nose block in the vertical/pitch direction relative to the trunion support at F.S. 110, W.L. 89 are determined from the tests described in Section 7.2.3. The relative lateral/roll/yaw influence coefficients of the total block relative to the fuselage structure at F.S. 110, W.L. 117 are established in the same manner. In the rigid ballast analysis the mass and inertia of the block in all directions are located at the composite center of gravity of the block and the lumped fuselage mass previously located at F.S. 110, W.L. 117. This composite center of gravity is at F.S. 110, W.L. 89. The relative and absolute degrees of freedom corresponding to the original rigid ballast model are shown in Figure 68 by a bar over the numerical identification.

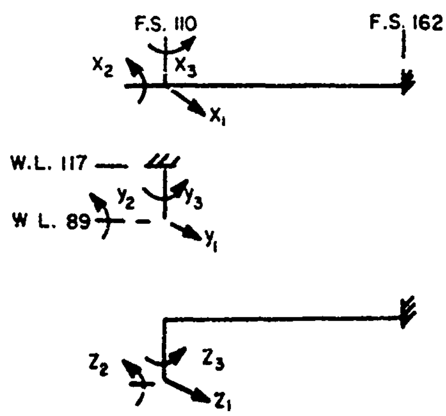
7.2.4 Nose Ballast Block (continued)

In order to revise the modeling of the nose ballast block the following assumptions are made.

(a) The vertical and pitching motion of the flexible forward portion of the block is defined by absolute degrees of freedom at the C.G. of this segment of the block.

(b) The vertical and pitching motion of the remainder of the block in addition to the lateral, yaw and rolling motion are defined by absolute degrees of freedom at the composite center of gravity of the block and the fuselage mass located at F.S. 110. This composite center of gravity is at F.S. 110, W.L. 89.

All absolute and relative degrees of freedom corresponding to this revised model are illustrated in Figure 68. The relative influence coefficients corresponding to degrees of freedom 28 and 34 are those obtained from the shake tests described in Section 7.2.3. The relative lateral, roll and yaw influence coefficients for degrees of freedom 12, 18 and 30 are developed from test data and the structural characteristics of the fuselage. These influence coefficients are computed utilizing the following transformation.



$$[\alpha_x]\{F_x\} = \{X\}$$

$$[\alpha_y]\{F_y\} = \{Y\}$$

The desired influence coefficients for relative degrees of freedom 12, 18 and 30 are defined by the matrix $[\alpha_z]$.

7.2.4 Nose Ballast Block (continued)

$$\{Z\} = [T_Z]\left\{\frac{x}{y}\right\}$$

$$\{F_x\} = [T_F]\{F_y\}$$

$$\{F_Z\} = \{F_y\}$$

Therefore:

$$\{Z\} = [T_Z]\left\{\frac{[ax][T_F]\{F_Z\}}{[ay]\{F_Z\}}\right\}$$

Letting:

$$[T_Z] = [T_{ZX} \mid T_{Zy}]$$

$$\{Z\} = \Big[[T_{ZX}][ax][T_F] + [T_{Zy}][ay]\Big]\{F_Z\}$$

Thus:

$$[a_Z] = [T_{ZX}][ax][T_F] + [T_{Zy}][ay]$$

The matrix $[a\,x]$ is defined from the structural analysis of Phase I and is given as:

$$[ax] = \begin{bmatrix} .4474 & 0.0 & .0121 \\ 0.0 & 0.0109 & 0.0 \\ .0121 & 0.0 & .00043 \end{bmatrix}$$

The matrix $[ay]$ is developed from test data and is defined as:

$$[ay] = \begin{bmatrix} 4.73 & .237 & 0.0 \\ .237 & .01585 & 0.0 \\ 0 & 0 & .0381 \end{bmatrix}$$

The matrices $[Tz]$ and $[T_F]$ are defined by geometry as:

$$[T_Z] = \begin{bmatrix} 1.0 & 28.0 & 0 & 1.0 & 0 & 0 \\ 0 & 1.0 & 0 & 0 & 1.0 & 0 \\ 0 & 0 & 1.0 & 0 & 0 & 1.0 \end{bmatrix}$$

$$[T_F] = \begin{bmatrix} 1.0 & 0 & 0 \\ 28 & 1.0 & 0 \\ 0 & 0 & 1.0 \end{bmatrix}$$

7.2.4 Nose Ballast Block (continued)

The resulting total influence coefficient matrix corresponding to degrees of freedom 12, 18 and 30 respectively is:

$$\left[\alpha z\right] = \begin{bmatrix} 10.721 & 0.542 & 0.012 \\ 0.542 & 0.027 & 0.0 \\ 0.012 & 0.0 & 0.039 \end{bmatrix}$$

Tail Ballast Block

Relative motion is measured between the tail block and the pylon fold hinge in the vertical, pitch and longitudinal directions. None is measured in the lateral direction. It is suspected that the relative motion is produced by local flexibility in the mounting blocks, tension bolts, backup plate and main support plate of the primary ballast (Figure 52). It would be virtually impossible to model this structure directly without a large expenditure of time and money. It is considered that the relative influence coefficients measured by the tests described in Section 7.3.3 will provide a reasonable approximation for the purpose of this analysis.

To include the effects of this local flexibility the assignment of relative and absolute degrees of freedom is modified as shown in Figure 69 The absolute and relative degrees of freedom representing the vertical, pitch and longitudinal motion of the ballast block are assigned at the center of gravity of the block at F.S. 758, W.L. 186.4. All other degree of freedom assignments remain unchanged.

7.3 Eighteen Bay Model with Ballast Flexibility

7.3.1 Dynamic Model

The complete degree of freedom definition utilized for this analysis is presented in Figures 70 and 71. The structural influence coefficient matrix corresponding to this model is modified in accordance with the procedures described in Section 7.2.

The Mass Matrix for this analysis is presented in Table 31.

7.3.2 Results

The results presented consist of analytical modes developed by both the rigid ballast model and the flexible ballast model as applicable. The modes identified for correlation with test data are:

7.3.2 Results (continued)

Mode	(CPM) Frequency	Model
1st Vertical Bending	438	Flexible Ballast
1st Lateral Bending	659	Flexible Ballast
Transmission Pitch	751	Flexible Ballast
Lateral Bending	735	Flexible Ballast
Lateral Bending	858	Flexible Ballast
Nose Block Vertical/ Transmission Pitch	933	Flexible Ballast
Nose Block Vertical	1043	Flexible Ballast
Forward Cabin Lateral	1105	Rigid Ballast
Second Vertical	1523	Rigid Ballast
Transmission Vertical/ Ramp Vertical Bending	1563	Rigid Ballast
Ramp Vertical	1394	Rigid Ballast
Torsion	1601	Rigid Ballast

The inclusion of the relative flexibility between the ballast and fuselage produces significant improvement in correlation particularly at frequencies below 1000 CPM where relative motion is measured. A detailed discussion of the degree of correlation follows:

Vertical/Pitch Modes

1st Vertical Bending

Analysis predicts this mode at 438 CPM as compared to a test value of 440 CPM (Figure 72) a difference of less than 1 percent. All modal amplitudes and nodes are in excellent agreement with test except for the vertical motion at the nose block. This difference is due to the technique applied in modeling the nose ballast flexibility where the impedance of the block is established dynamically at a higher frequency.

Transmission Pitch

An error of 1.5 percent exists between the predicted frequency of 751 CPM and that of the test mode (Figure 74). It is apparent from examination of the two shapes that the dynamic

7.3.2 Transmission Pitch (continued)

impedance of the tail ballast block established by the test procedure of Section 7.2 did not produce accurate results in this area. The smaller vertical ramp motion predicted by analysis is consistent with the smaller predicted vertical motion at the tail ballast block itself. Considering only the mode shape in the cabin area which is controlled by the nose ballast and simulated transmission, the shape correlation is rated good based upon the criteria established in Section 6.

Nose Block Vertical/Transmission Pitch

The analytically predicted frequency of 933 CPM differs from the test value of 970 CPM (Figure 77) by 4 percent. As is the case in the transmission pitch mode the failure to accurately establish the dynamic impedance of the tail ballast block produces discrepancies between predicted and test shapes in the ramp area. The shape correlation of the cabin roof is considered fair to good with nodes within 20 inches of test and amplitudes generally within 20 percent of test. Examination of the predicted shape indicates that the number of nodes do not agree with test. However, the number and location of changes in curvature are in good agreement with test.

Since this mode is controlled by the relative flexibility of the ballast, which is not defined exactly, the degree of shape correlation is considered good.

Nose Block Vertical

The frequency error in predicting this mode is 1 percent. The mode is encountered at 1050 CPM in test while the modified flexible ballast analysis predicts the mode at 1043 CPM (Figure 78). As is the case Nose Block Vertical/Transmission Pitch Mode, the determination of the ballast flexibility strongly affects the prediction of this mode. The shape is rated fair.

Second Vertical Bending

Analysis predicts this mode at 1523 CPM as compared to a test frequency of 1290 CPM (Figure 80). This mode is locally controlled by the structure in the ramp area and is very sensitive to modeling in that area. As indicated in Section 6.0 all the ramp mass is lumped at F.S. 567, thus creating artificial lateral frame modes at F.S. 567. These artifical local frame modes exist in the frequency range of all ramp controlled vertical modes, and in fact, all vertical modes normalize on the lateral degrees of freedom at F.S. 567. These artificial lateral

7.3.2 Second Vertical Bending (continued)

frame modes coupling with the low generalized mass vertical ramp modes produce frequency shifts and mode shape distortions which contribute to a degredation in degree of correlation. In addition significant coupling of all modes above 1200 CPM exists in the actual test which makes accurate definition of actual mode shapes more difficult at higher frequencies. This will be discussed in more detail in subsequent sections of this report. The resulting mode shape correlation is considered fair.

Transmission Vertical/Ramp Vertical Bending

The preceding discussion of the Second Vertical Bending mode correlation applies to this mode as well. The difference between the analytically predicted frequency of 1563 CPM and the test frequency of 1425 CPM (Figure 81) is 8 percent. The mode shape correlation varies from fair to good.

Ramp Vertical Bending

Although the test mode and the analytical mode (Figure 82) contain strong similarities, enough differences exist to rate the shape as poor. To a great degree the accuracy of establishing the actual test shape is strongly controlled by the high degree of coupling between this mode at 1640 CPM and other ramp vertical modes at 1290 and 1452 CPM. The frequency error in predicting this mode is 18 percent.

Lateral/Torsion Modes

The attempts to model the lateral, roll and yaw flexibility of the nose ballast block are not as successful as in the vertical/pitch sense. This is evidenced by the failure to predict the local Nose Block Lateral/Roll mode encountered in test at 930 CPM (Figure 76). In addition the eccentrically mounted 3000 lb. nose ballast block places a strong emphasis on defining the elastic axis and torsional constant of the cockpit, parameters not considered critical in the dynamic analysis of a standard aircraft. In general the modes which are stronly controlled by the ballast block exhibit poor correlation. To a great extent, this may be due to the difference in technique utilized in modeling the lateral/roll/yaw flexibility of the nose ballast, as compared to that in the vertical/pitch direction. Due to degree of freedom limitations and time constraints the local lateral flexibility of the nose ballast supports has been lumped with the total flexibility of the fuselage from F.S. 162 forward (Section 7.2.4). In the vertical sense the nose block flexibility has been treated

7.3.2 Lateral/Torsion Modes (continued)

separately. Time constraints did not permit further iteration of this modeling technique.

Of principal importance, however, is the substantial improvement in the correlation of the first Lateral Bending Mode as compared to the results achieved in Phase I (Section 6). The revised Phase II analysis predicts a frequency of 659 CPM, as compared with a test value of 615 cpm (Figure 73). This error of 7 percent is considerably better than the 33% error achieved in Phase I. In addition, the analysis correctly predicts the significant change in the actual mode shape between that encountered in Phase I and the shape of the Phase II 1st Lateral Bending Mode. The shape correlation is considered good to excellent.

Poor correlation of the ramp controlled torsion mode at 1310 CPM (Figures 83 and 84) is achieved. The corresponding analytical mode shapes predicted at 1600 CPM are also presented in Figures 83 and 84. As is the case with the higher frequency vertical modes, modeling limitations and difficulty in defining actual test mode shapes at these frequencies contribute to the lack of correlation.

A summary of the Phase II correlation is presented in Table 32.

7.4 Discussion of Results

7.4.1 Modeling

Including ballast to replace appendages removed prior to the Phase I test and correlation has resulted in a substantial improvement in correlation. In particular, the Phase I difficulties identified as sensitivity of the analysis to beam modeling of the forward fuselage, the "rigid" frame at F.S. 442, and the coupling of fuselage and local frame modes in the absence of representative mass distributions are almost totally eliminated. In particular this results in an obvious improvement in the frequency and shape correlation of the Transmission Pitch and list Lateral Bending Modes.

It must be emphasized that in order to achieve the degree of correlation obtained, modeling of flexibilities within the ballast itself was required. This modeling has been successfully accomplished in the vertical/pitch direction but did not prove successful in predicting lateral/torsion modes. It is apparent that the FRAN/vibration analysis is able to accurately predict significant changes in the characteristics and frequencies of fuselage and transmission modes when the structural data base is accurately defined. Further improvement in correlation would have been achieved had a more detailed definition of the ballast flexibility been defined by static tests prior to dynamic testing and correlation.

Difficulty in accurately predicting the higher frequency ramp controlled modes still persists, although a significant improvement over the Phase I results as achieved. From the standpoint of modeling it is apparent that a 200 degree of freedom model is inadequate for a vehicle which contains a cargo ramp since this constraint necessitates oversimplification of the dynamic model in this region of the fuselage. In addition, the test procedure employed, namely a single rotor head shaker, does not provide a means of identifying uncoupled mode shapes at higher frequencies.

7.4.2 Testing

In general modes below 1000 CPM are sufficiently uncoupled so that a single rotor head shaker will provide test data which enables accurate definition of uncoupled mode shapes. (Figure 85, 440 CPM). At higher frequencies insufficient frequency separation exists to permit accurate definition of uncoupled mode shapes.

The frequency response trace of Figure 85 represents the in-phase and quadrature response of a vertical accelerometer due to

7.4.2 Testing (continued)

vertical rotor head excitation as frequency is varied. At a resonant frequency of an uncoupled mode the quadrature response peaks and the in-phase response crosses the zero axis. This characteristic is quite evident in the First Vertical Bending Mode at 440 CPM.

The existence of modal coupling is revealed by a quadrature peak which is not coincident with an in-phase zero crossing. Due to the proximity of modes the in-phase and quadrature response represent the simultaneous contribution of several modes. This is illustrated in particular by the interaction of the second Vertical and Transmission Vertical Modes in the range of 1200 - 1500 CPM (Figure 65). Thus the mode shapes resulting from test data of this type cannot be accurate and the lack of a higher degree of shape correlation at these frequencies cannot be identified as being due to analysis only.

In order to avoid this pitfall one or more roving shakers are required. The structure must be excited at locations which are antinodes of the mode in question and are simultaneous nodes of adjacent modes. This would uncouple the response and produce an improved definition of the shape of the actual mode.

7.5 Conclusions and Recommendations

1. The FRAN vibration analysis is capable of accurately predicting resonant frequencies and mode shapes of complex aircraft type structures when the structural data base is accurately defined.

2. To insure this accuracy in the input data, it is recommended that appendages of a character not amenable to accurate or economical structural analysis be statically tested to determine flexibility coefficients required for dynamic analysis.

3. The FRAN/vibration analysis program permits a rapid and economical evaluation of structural and mass changes. Only the immediate substructure in question need be altered to reflect structural or mass distribution modifications.

7.5 Conclusions and Recommendations (continued)

4. Excellent results may be expected in predicting all transmission and fuselage modes for a vehicle without a cargo ramp. Greater detail is required than that employed to accurately predict ramp controlled modes.

5. A 200 degree of freedom dynamic analysis may not be adequate for vehicles with cargo ramps.

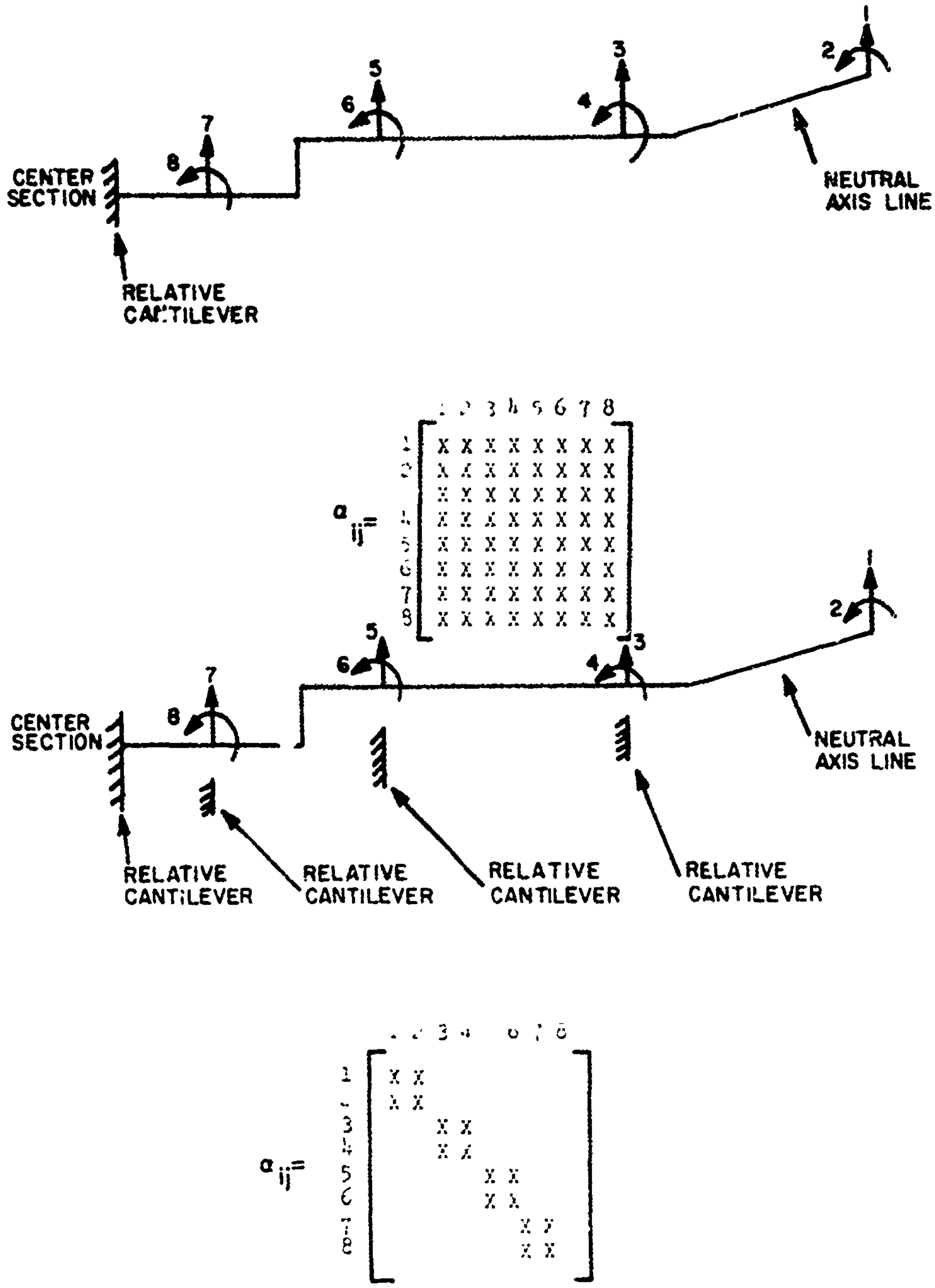


Figure 1. Substructure Analysis of Influence Coefficients

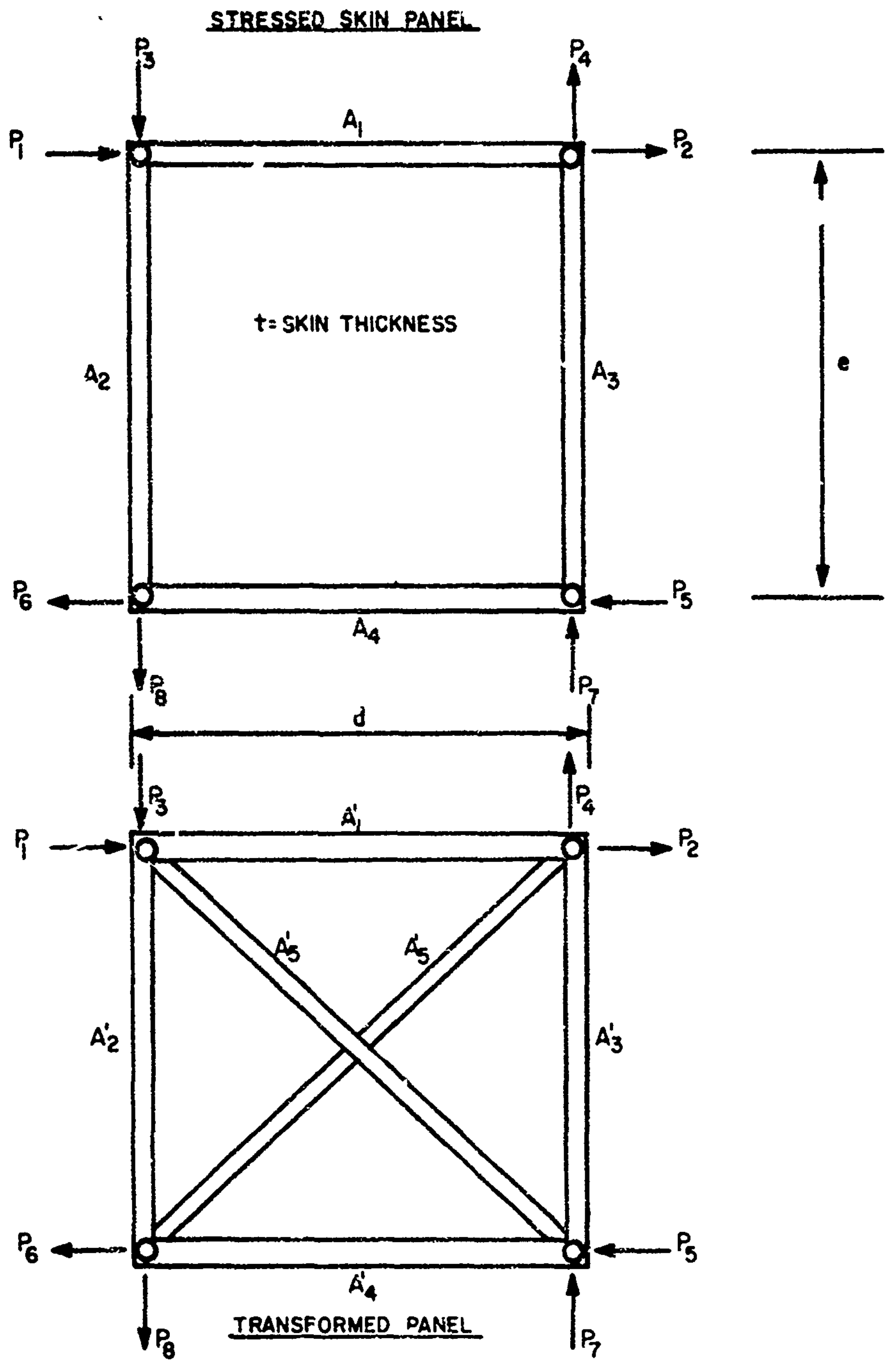
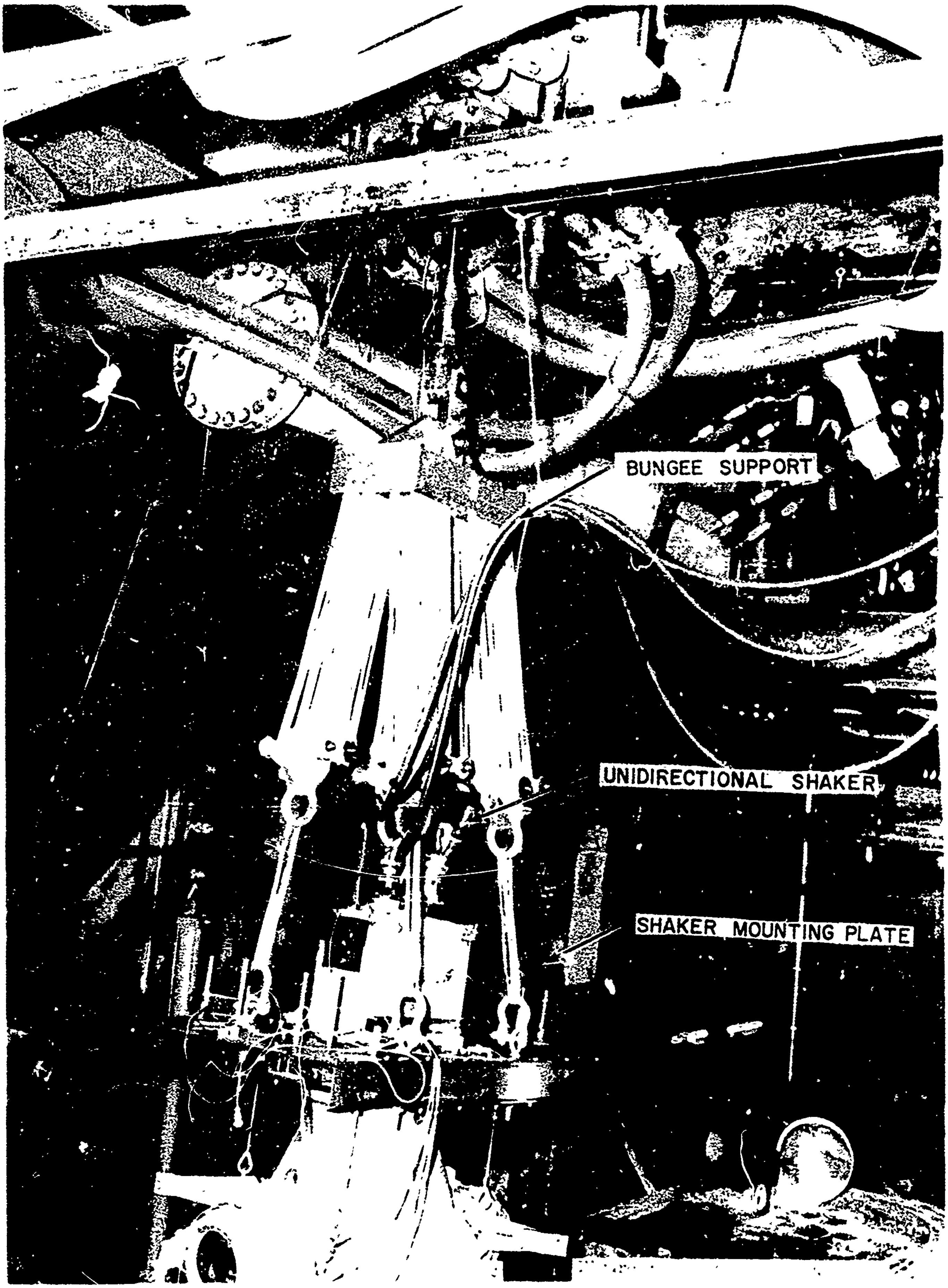


Figure 2. PPFRAN Skin Panel Transformation


BUNGEE SUPPORT
UNIDIRECTIONAL SHAKER
SHAKER MOUNTING PLATE

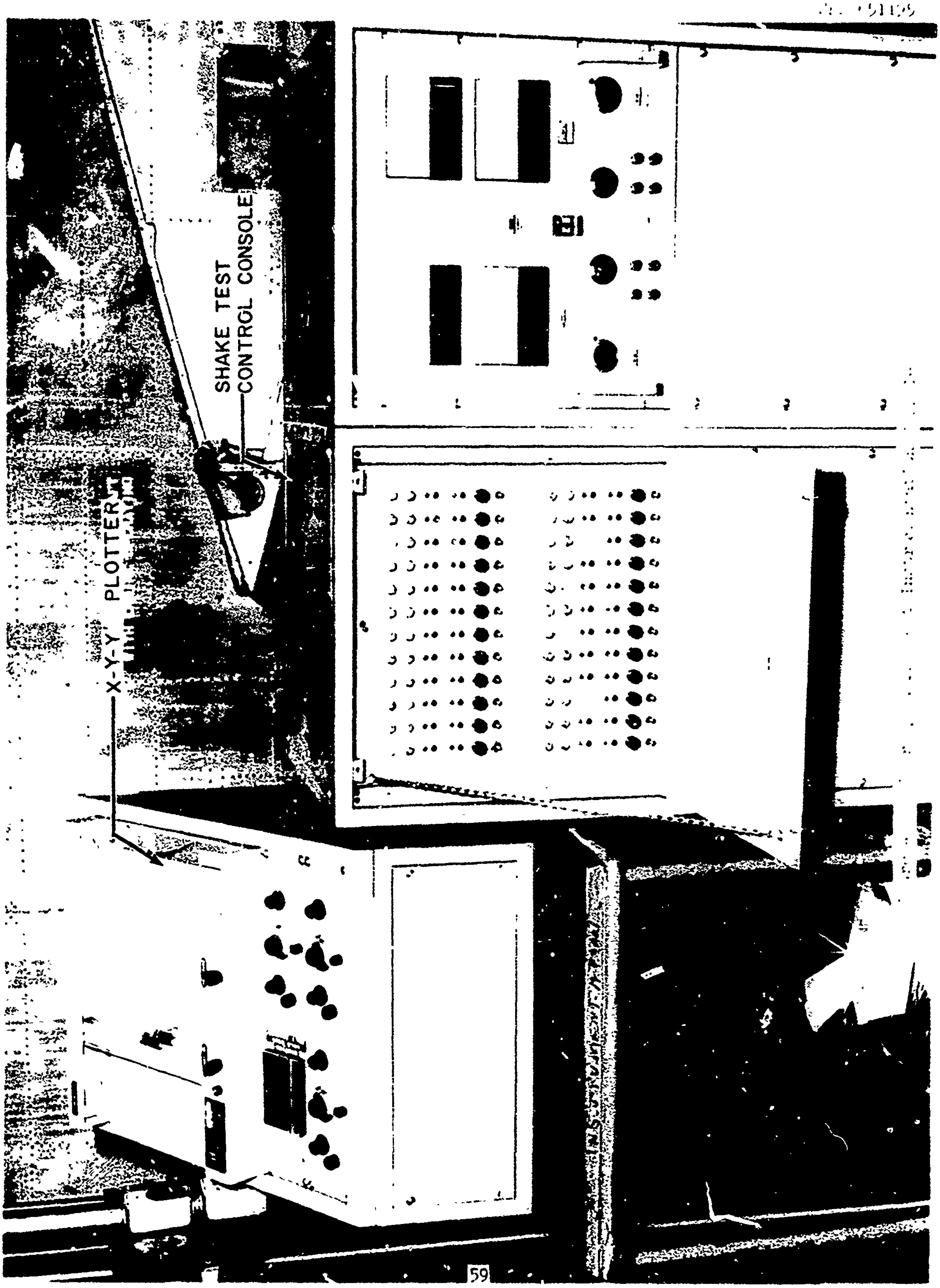
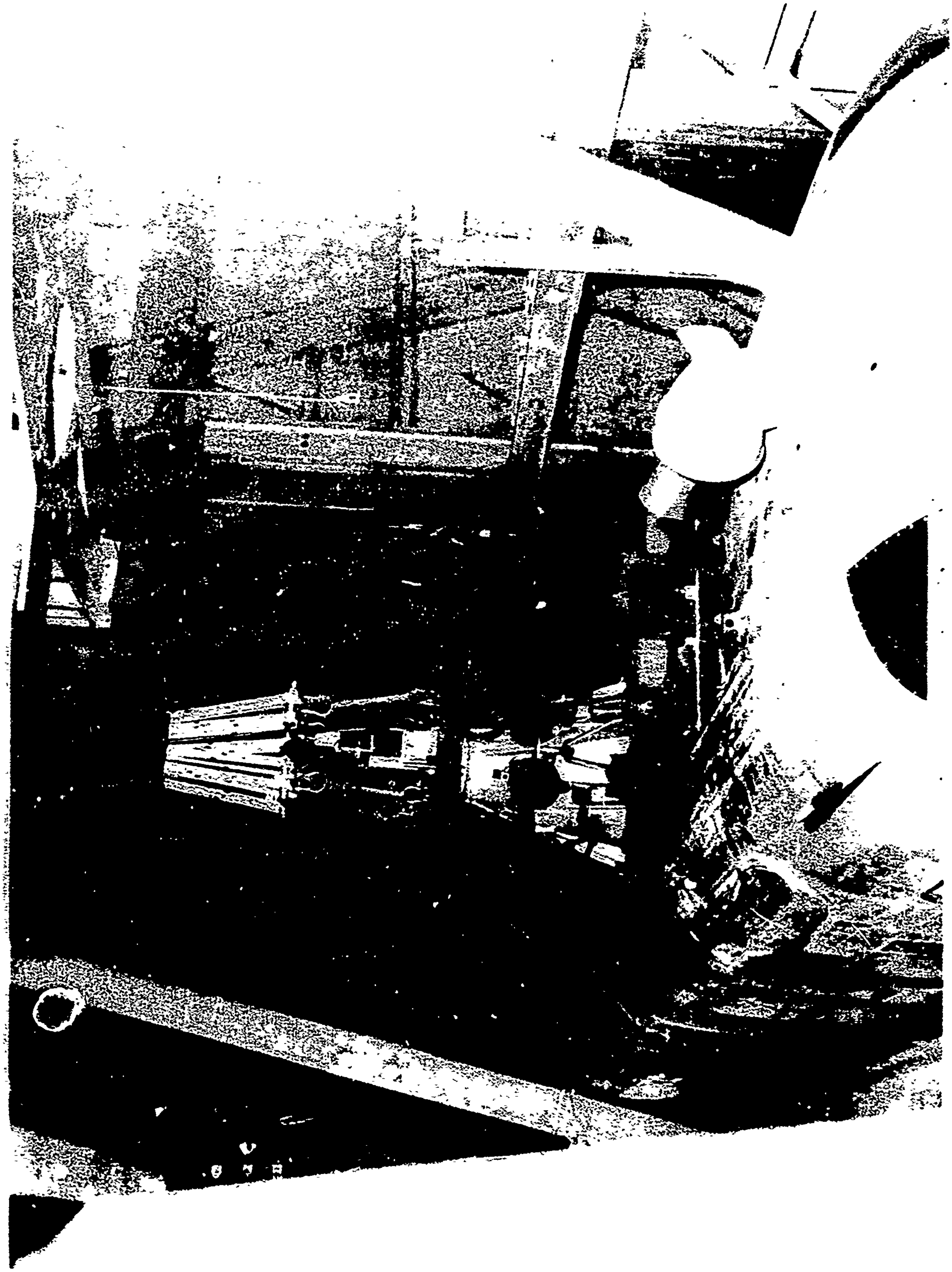
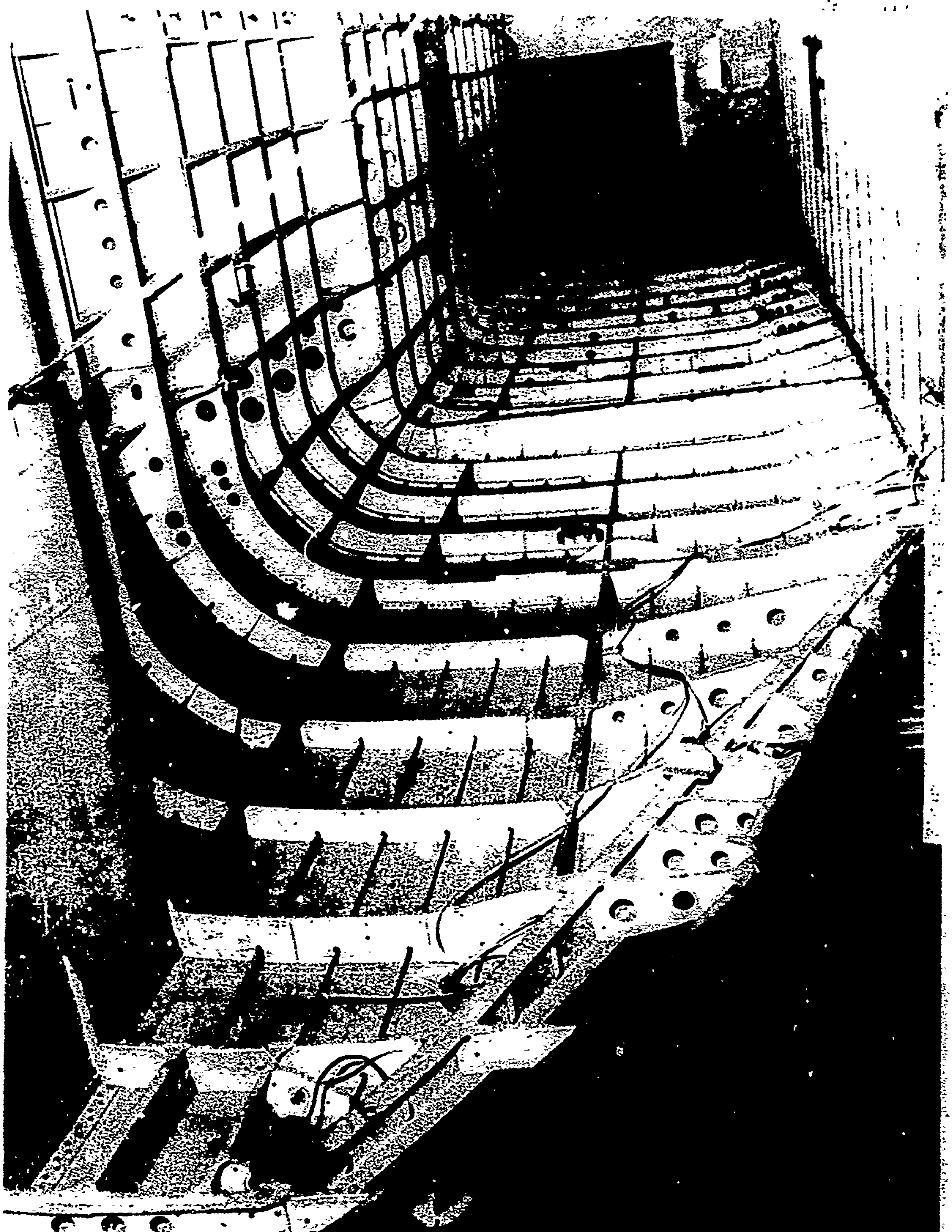

X-Y-Y' PLOTTER
SHAKE TEST CONTROL CONSOLE

Figure 5-[illegible] Real and Imaginary Frequency Sweeps

Figure · Test Article, Aft View





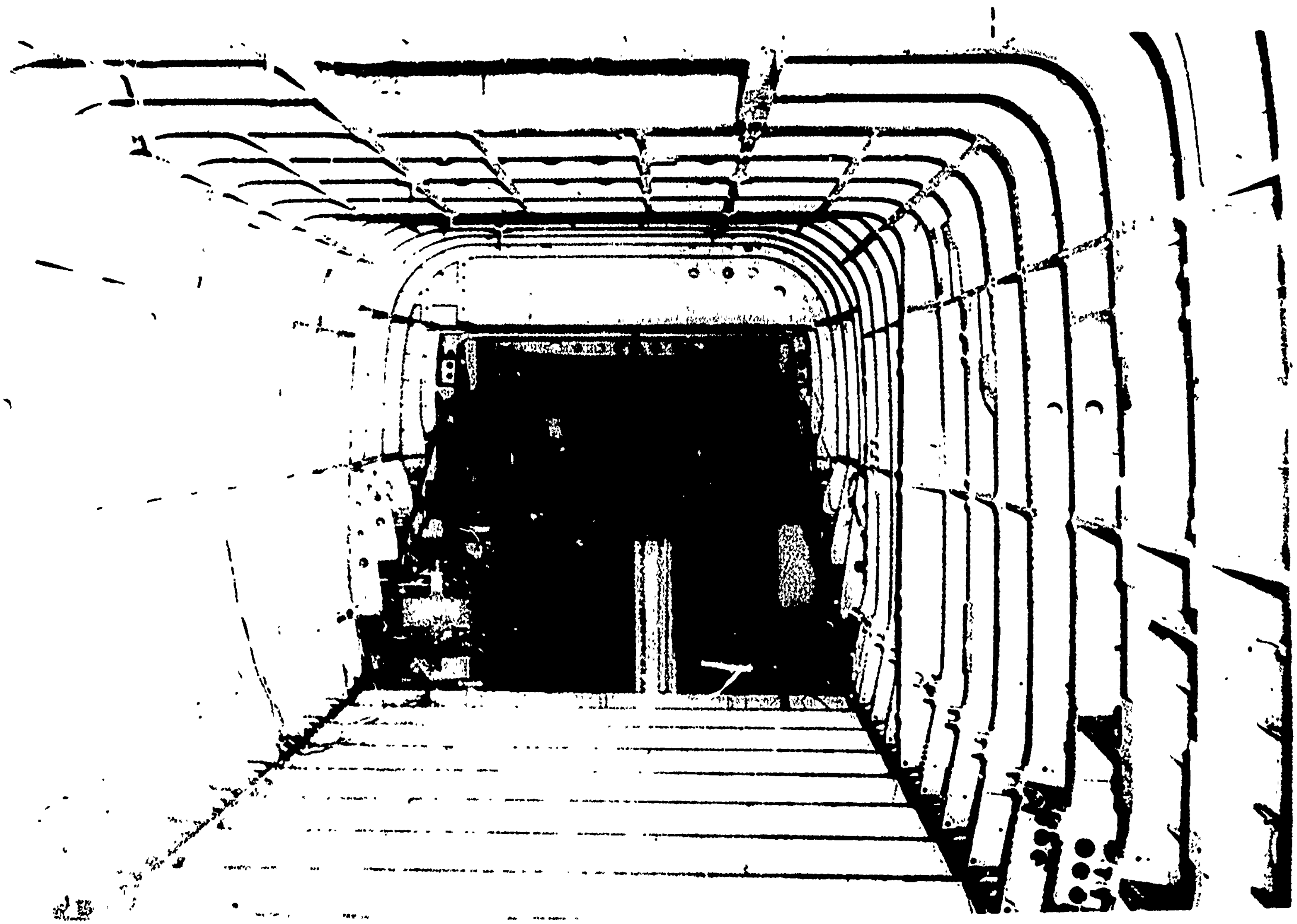


Figure [illegible] Test Article, Interior View

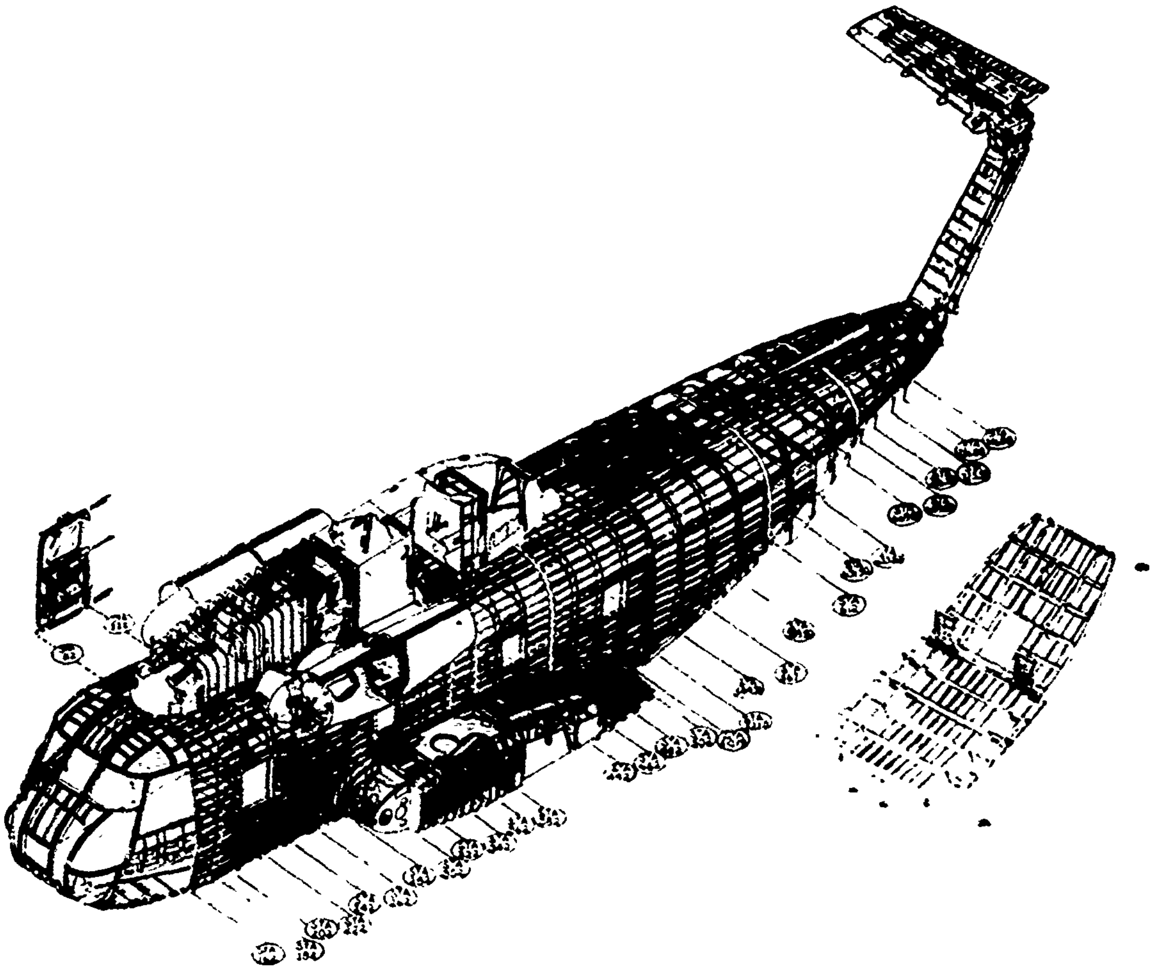


Figure 10. CH-53A General Arrangement

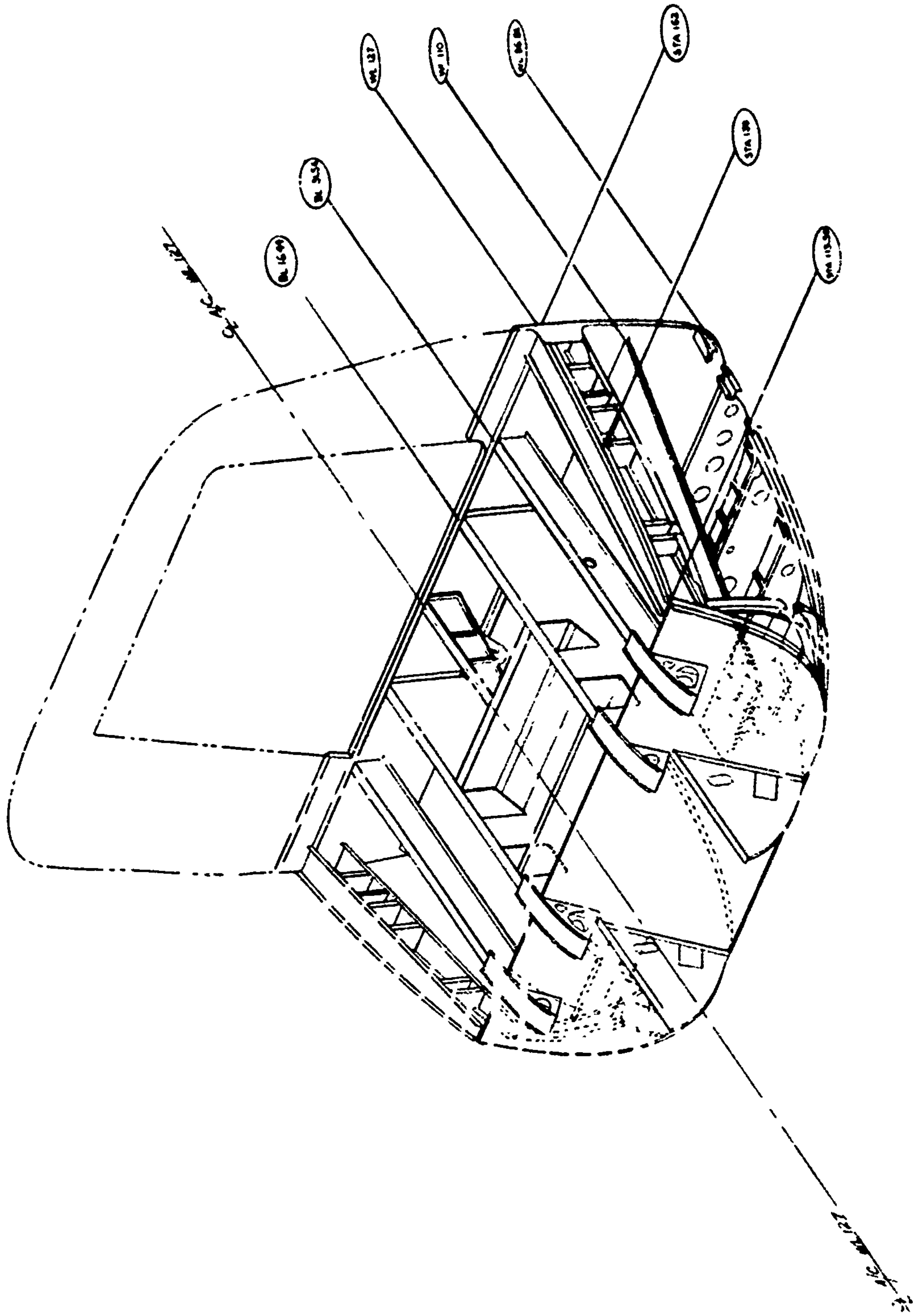


Figure 11. Cockpit Structural Arrangement

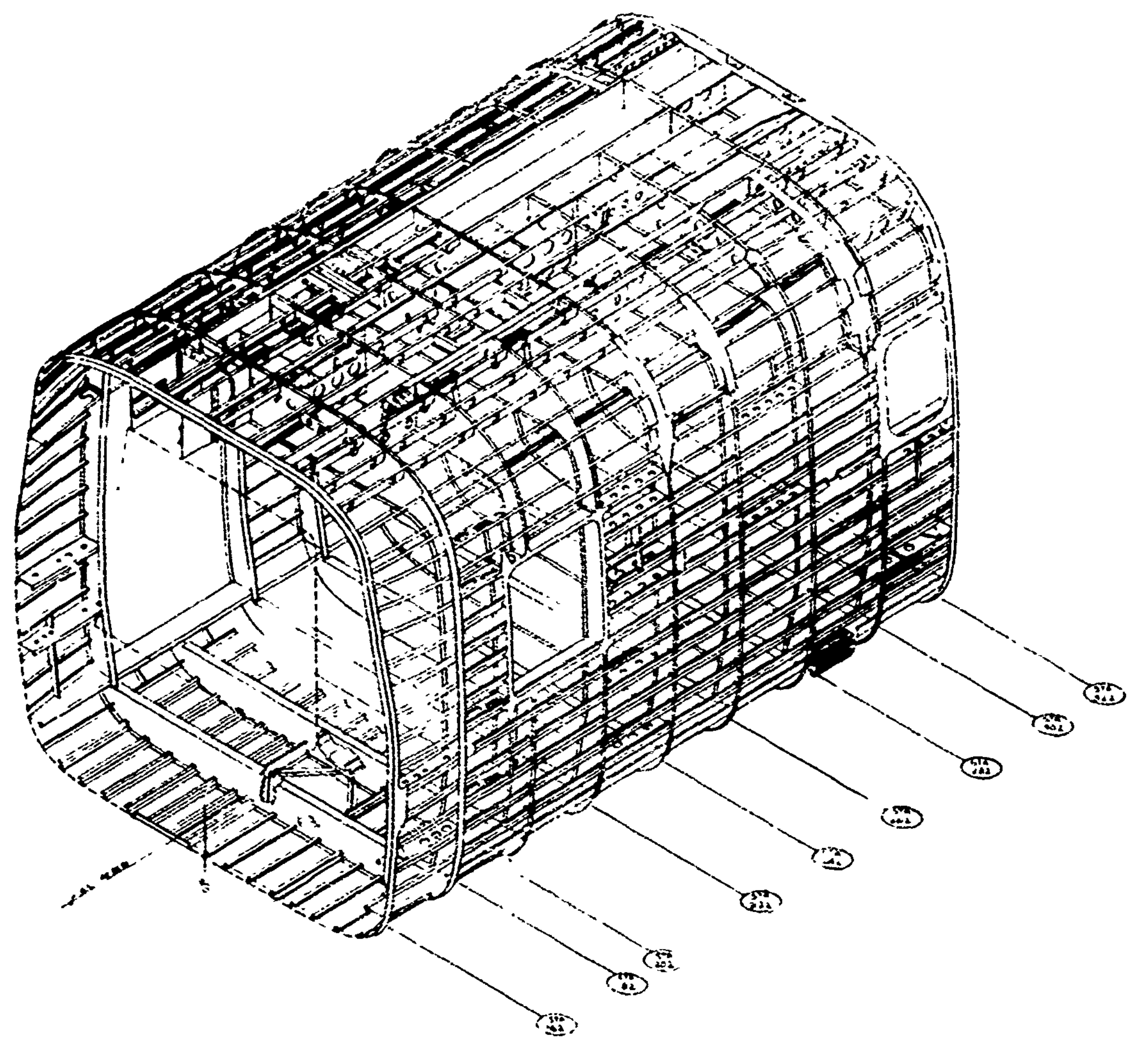


Figure 12. Forward Cabin Structural Arrangement

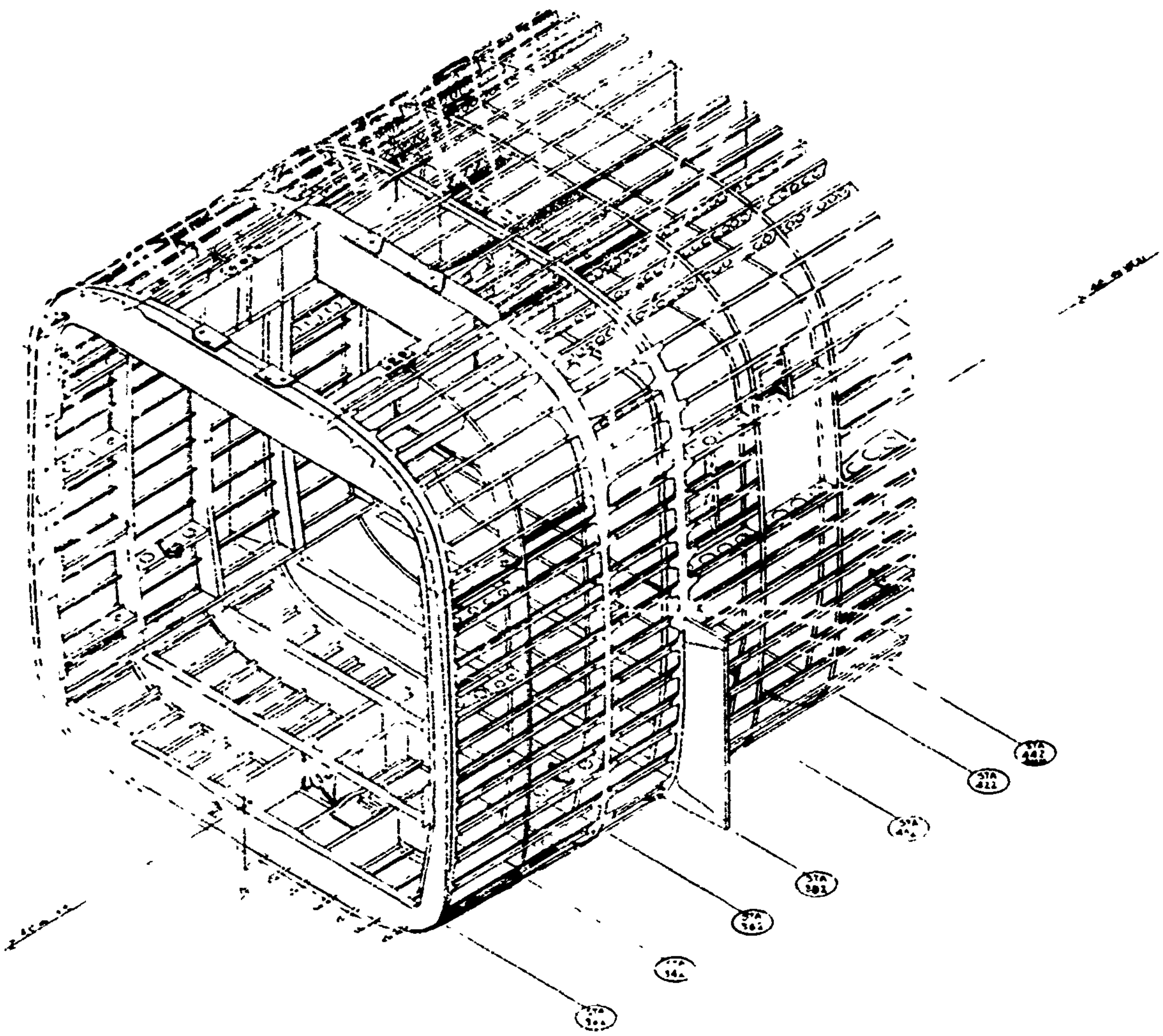


Figure 13. Transmission Support Section, Structural Arrangement

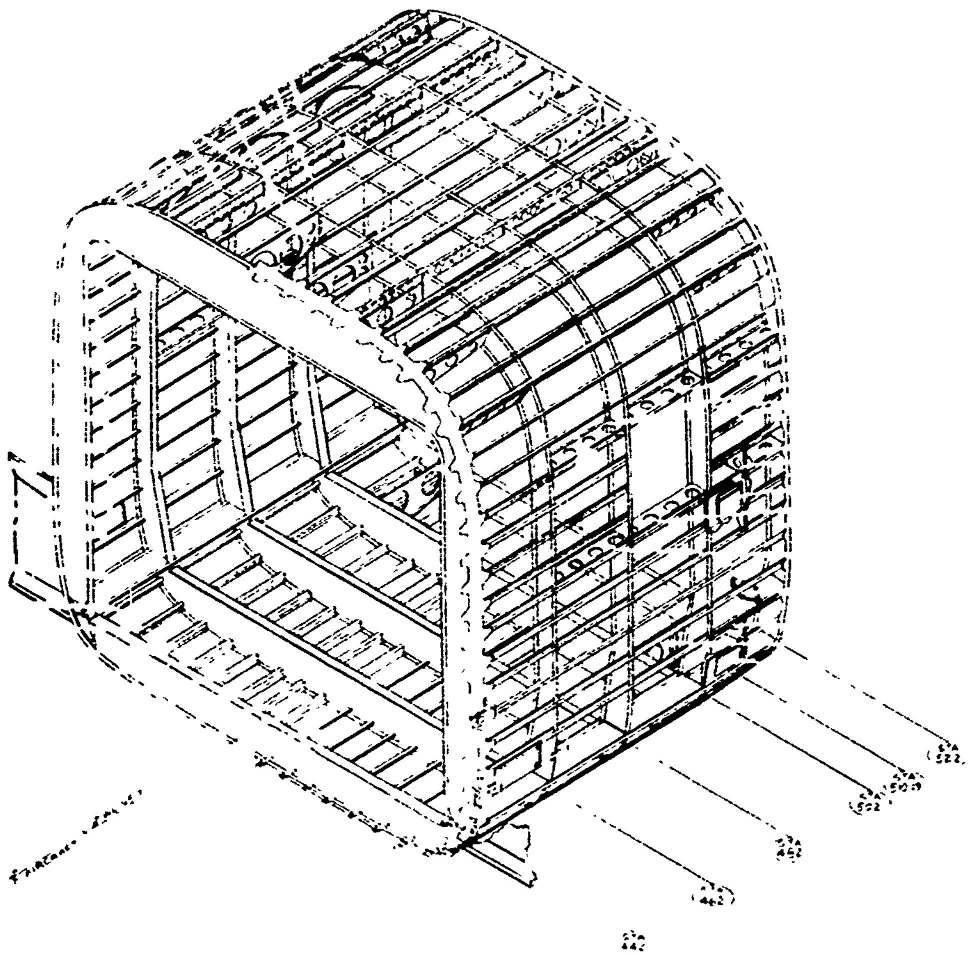


Figure 14. Aft Cabin Structural Arrangement

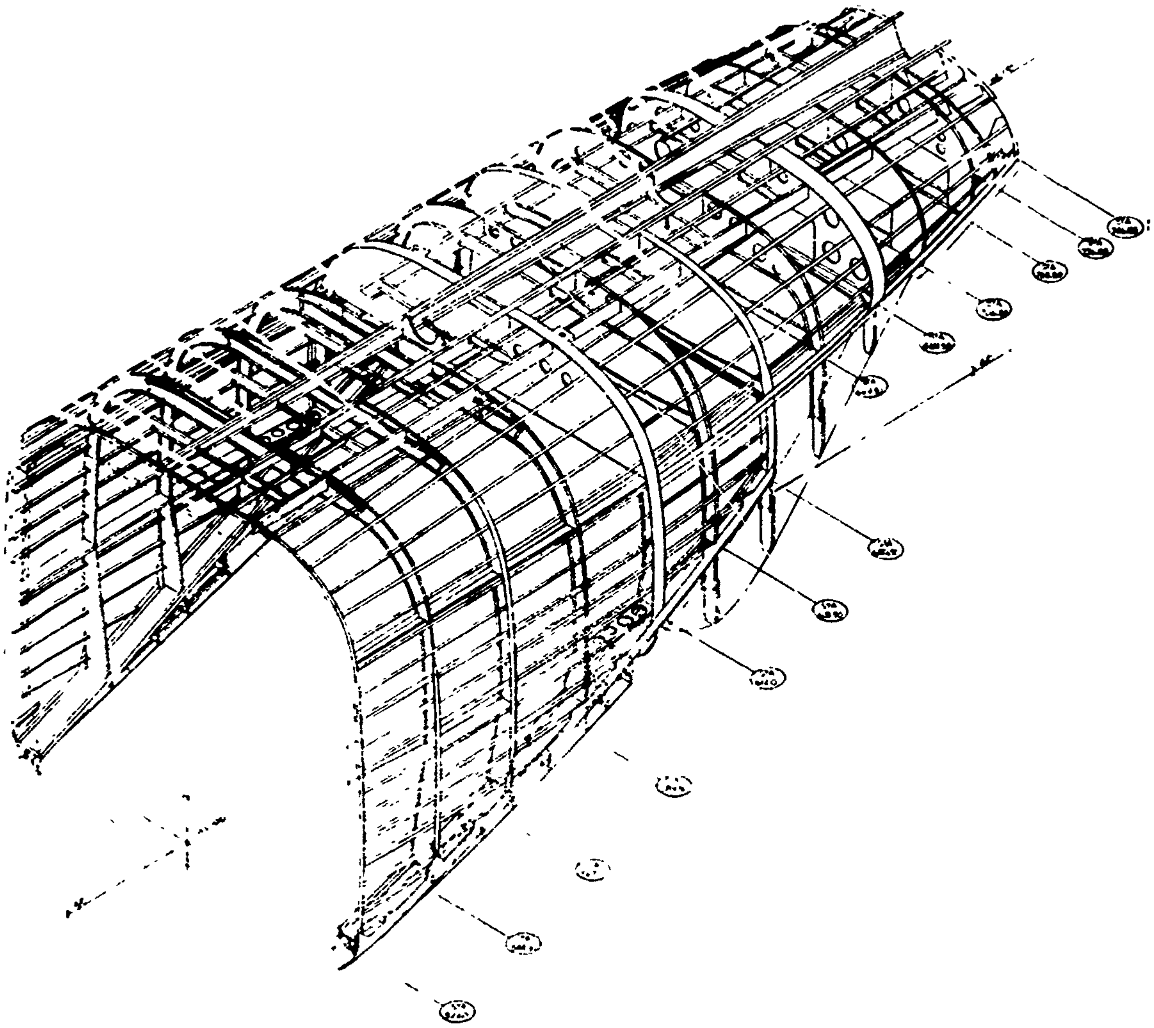


Figure 15. Ramp Area Structural Arrangement

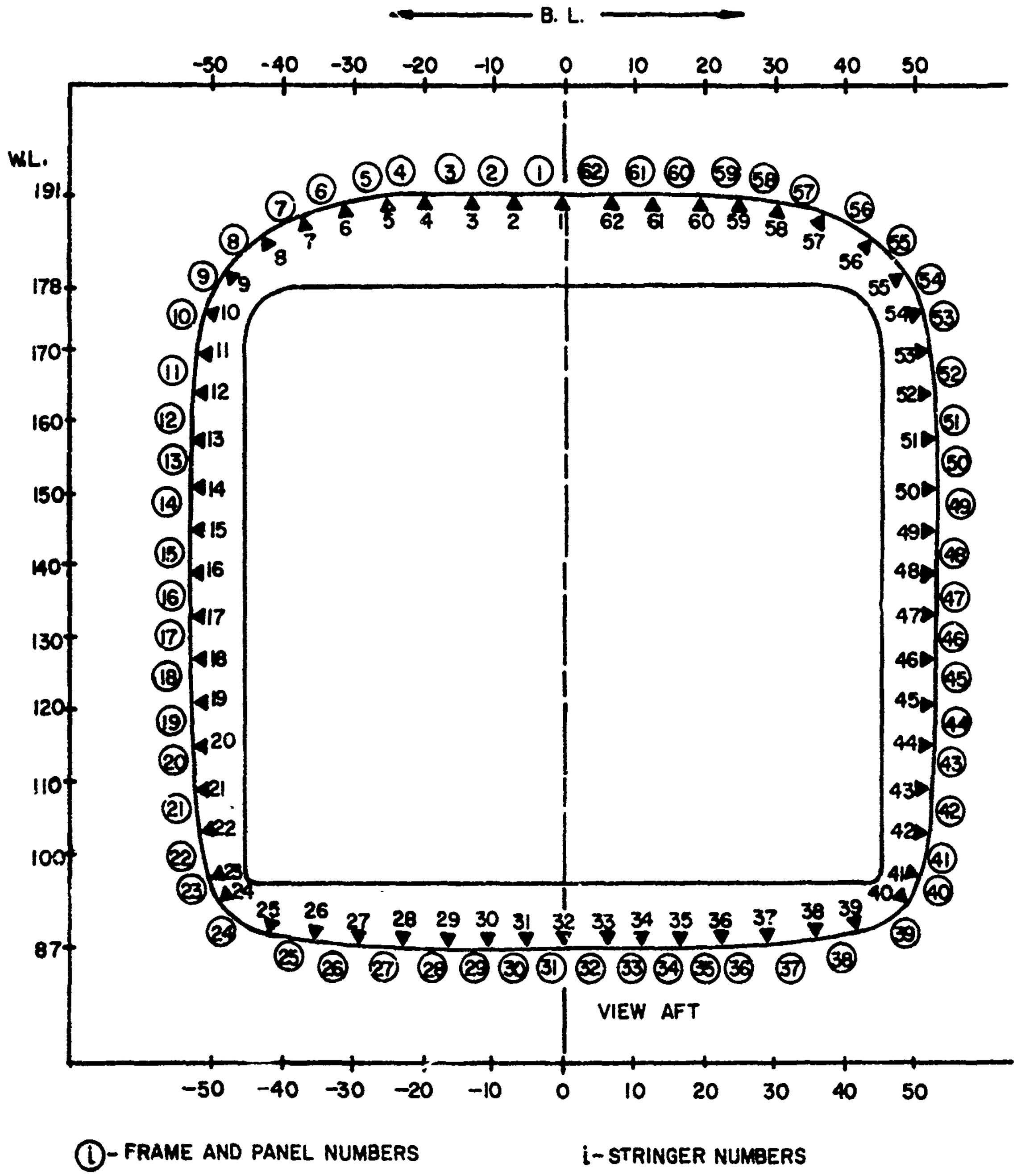


Figure 16 Sixty-Two Stringer Locations, FS 162-522

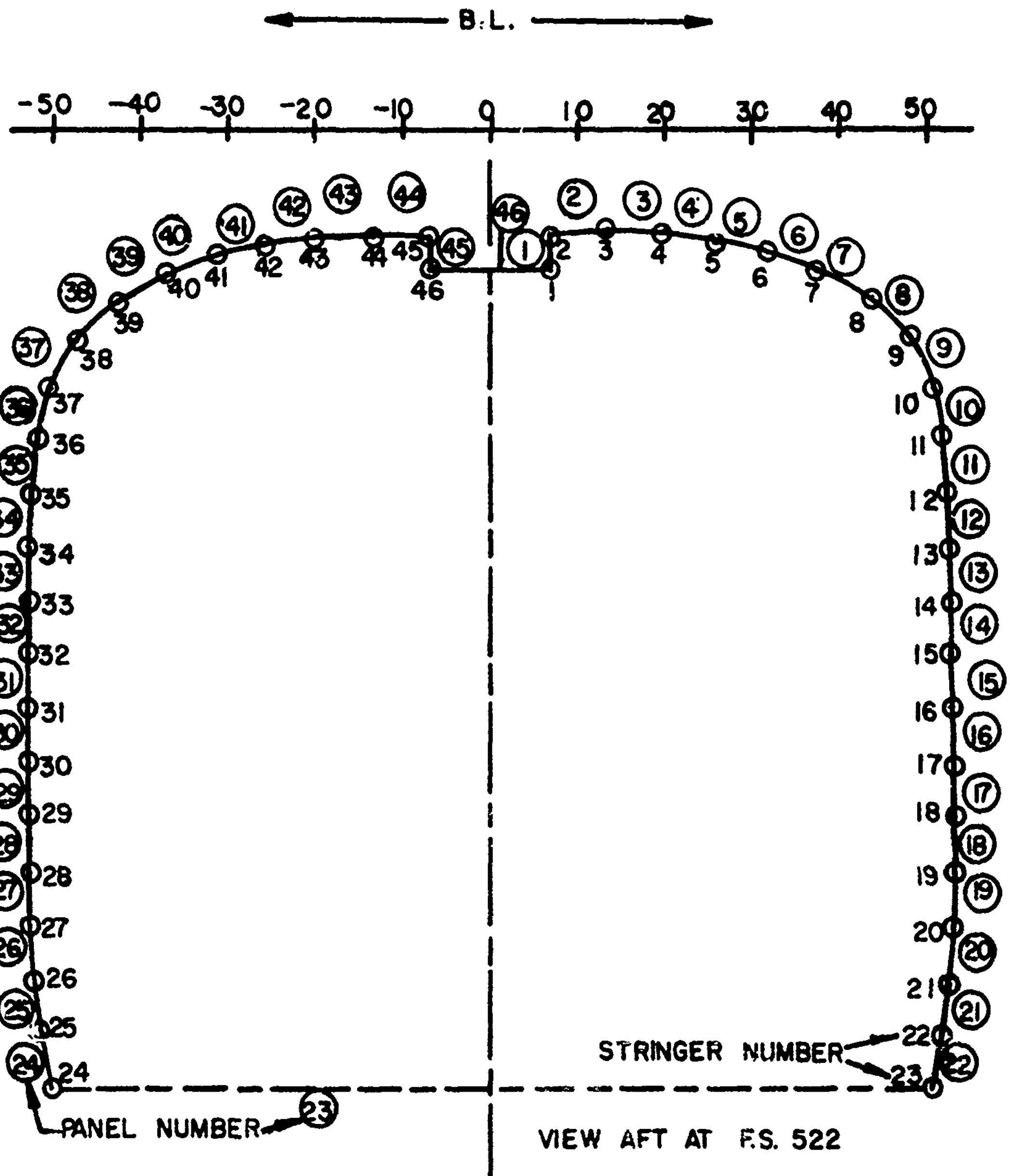


Figure 17 Stringer and Panel Identification, Ramp, FS 522-612

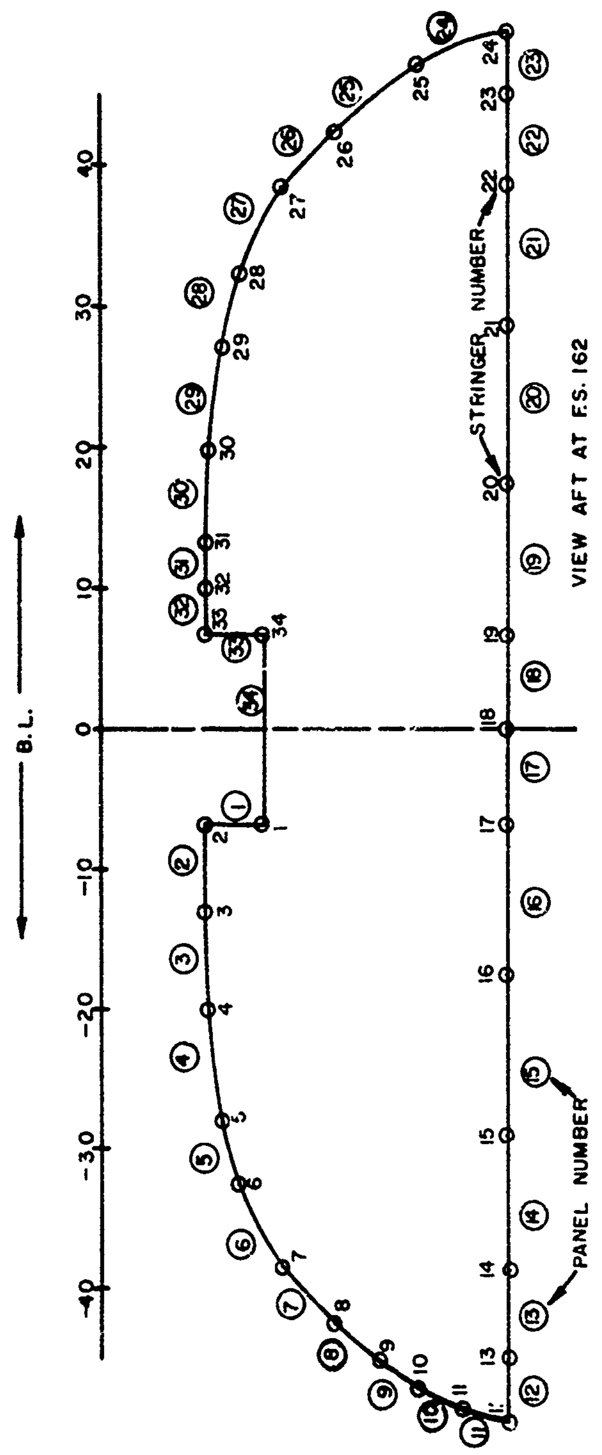
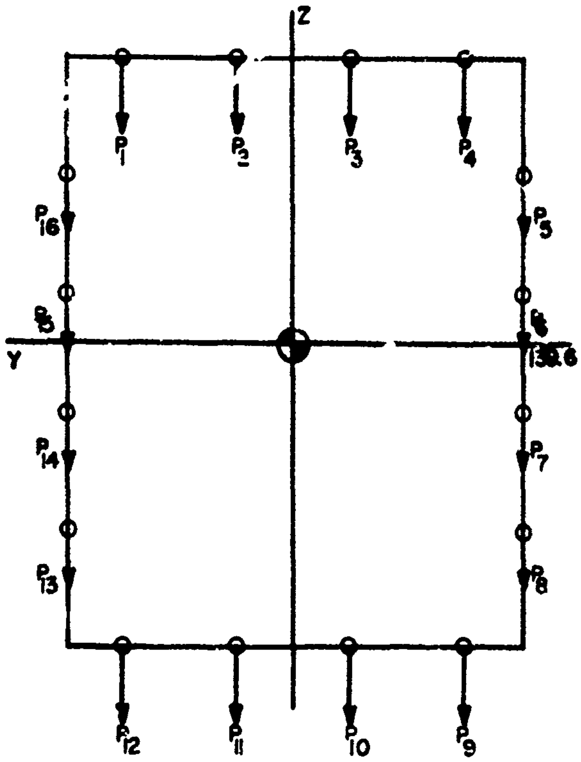
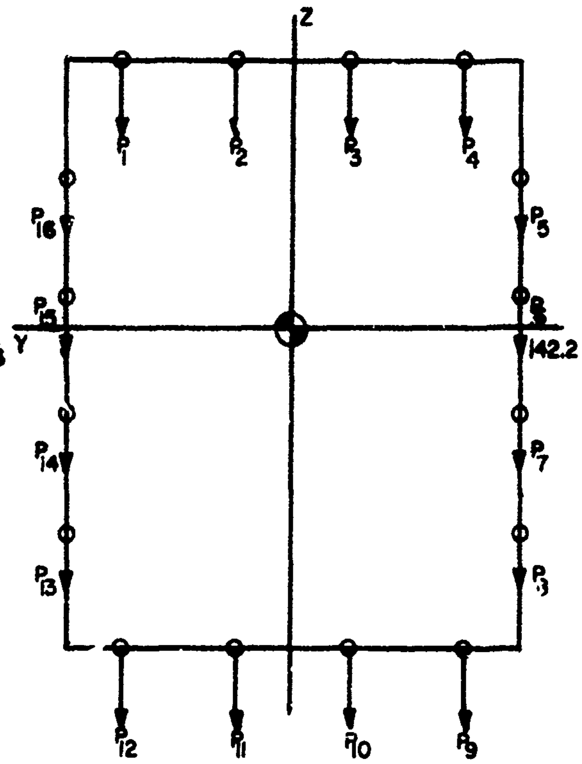


Figure 18 Stringer and Panel Identification, Tail Cone, FS 612-746



STATION 282

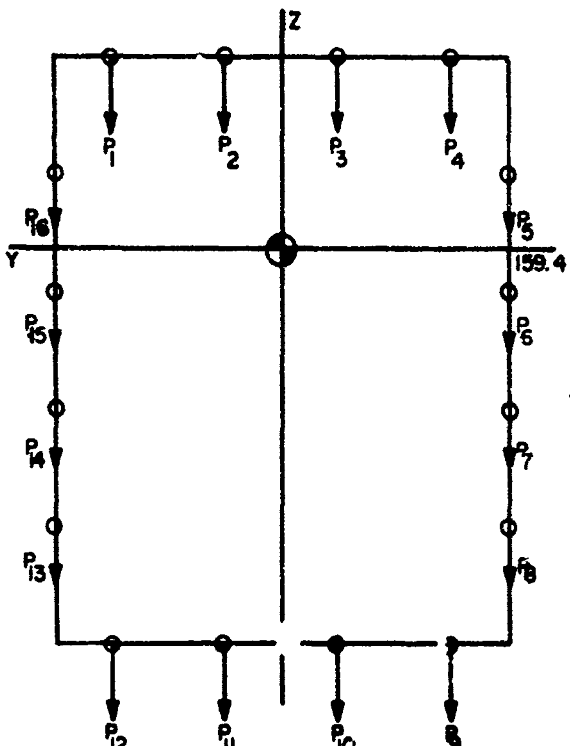


STATION 302

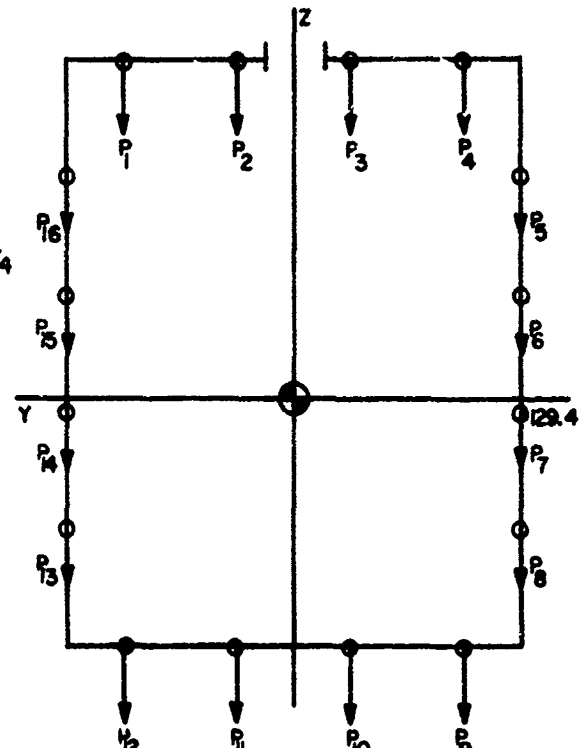
NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L IN
P_1	6.69	0.21	-39.75	191.0
P_2	6.69	0.21	-13.25	191.0
P_3	6.69	0.21	+13.25	191.0
P_4	6.69	0.21	+39.75	191.0
P_5	6.15	0.19	+53.00	178.0
P_6	6.47	0.20	+53.00	152.3
P_7	7.13	0.22	+53.00	126.3
P_8	4.12	0.13	+53.00	100.0
P_9	7.10	0.22	+39.75	87.0
P_{10}	7.10	0.22	+13.25	87.0
P_{11}	7.10	0.22	-13.25	87.0
P_{12}	7.10	0.22	-39.75	87.0
P_{13}	4.12	0.13	-53.00	100.0
P_{14}	7.13	0.22	-53.00	126.3
P_{15}	6.47	0.20	-53.00	152.3
P_{16}	6.15	0.19	-53.00	178.0
TOTAL	102.9	3.20	0	139.6

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	9.17	0.29	-39.75	191.0
P_2	9.17	0.29	-13.25	191.0
P_3	9.17	0.29	+13.25	191.0
P_4	9.17	0.29	+39.75	191.0
P_5	9.24	0.29	+53.00	178.0
P_6	7.87	0.24	+53.00	153.6
P_7	8.79	0.27	+53.00	127.6
P_8	7.27	0.23	+53.00	100.0
P_9	7.97	0.25	+39.75	87.0
P_{10}	7.97	0.25	+13.25	87.0
P_{11}	7.97	0.25	-13.25	87.0
P_{12}	7.97	0.25	-39.75	87.0
P_{13}	7.27	0.23	-53.00	100.0
P_{14}	8.79	0.27	-53.00	127.6
P_{15}	7.87	0.24	-53.00	153.6
P_{16}	9.24	0.29	-53.00	178.0
TOTAL	134.9	4.19	0	142.2

Figure 19 Nodal Mass Distribution-CH53-A, Cabin and Ramp Area



STATION 322

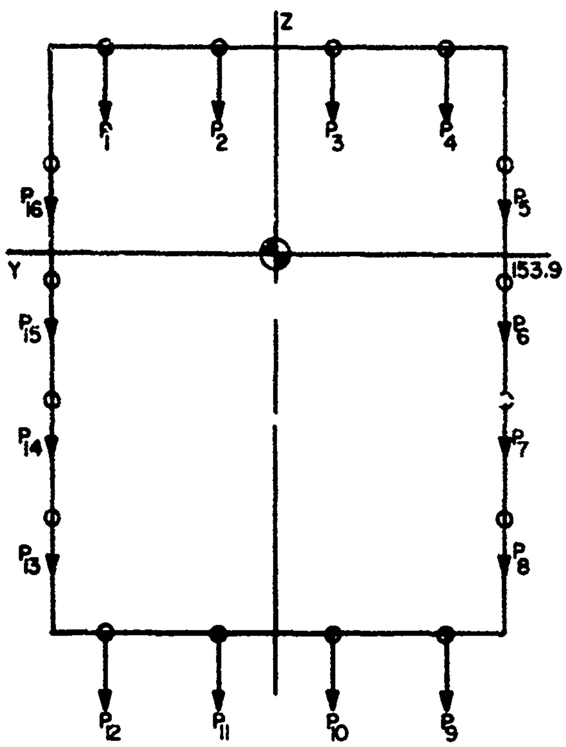


STATION 342

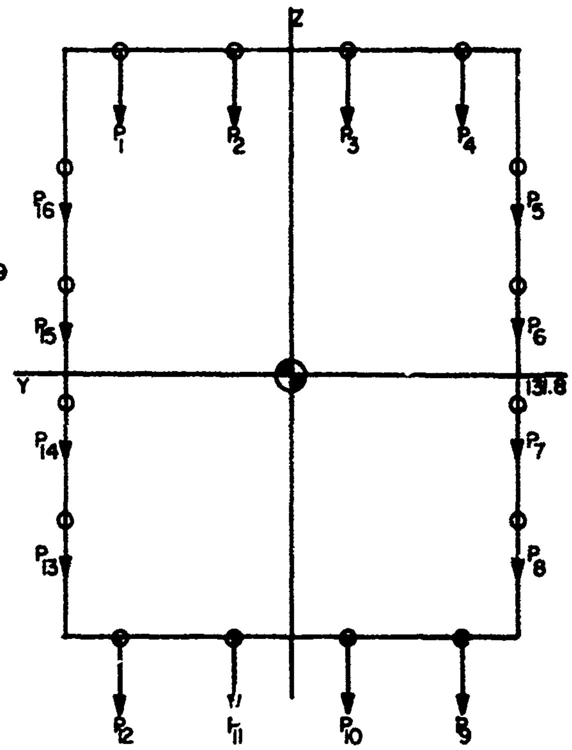
NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	29.87	0.93	-39.75	191.0
P_2	29.87	0.93	-13.25	191.0
P_3	29.87	0.93	+13.25	191.0
P_4	29.87	0.93	+39.75	191.0
P_5	35.60	1.11	+53.00	175.2
P_6	9.37	0.29	+53.00	142.8
P_7	9.97	0.31	+53.00	119.6
P_8	11.17	0.35	+53.00	100.0
P_9	8.52	0.26	+39.75	87.0
P_{10}	8.52	0.26	+13.25	87.0
P_{11}	8.52	0.26	-13.25	87.0
P_{12}	8.52	0.26	-39.75	87.0
P_{13}	11.17	0.35	-53.00	100.0
P_{14}	9.97	0.31	-53.00	119.6
P_{15}	9.37	0.29	-53.00	142.8
P_{16}	35.60	1.11	-53.00	175.2
TOTAL	285.6	8.88	0	159.4

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	10.05	0.31	-39.75	191.0
P_2	3.40	0.11	-13.25	191.0
P_3	3.40	0.11	+13.25	191.0
P_4	10.05	0.31	+39.75	191.0
P_5	8.64	0.27	+53.00	178.0
P_6	9.36	0.29	+53.00	147.2
P_7	7.92	0.25	+53.00	121.2
P_8	10.18	0.32	+53.00	100.0
P_9	12.38	0.38	+39.75	87.0
P_{10}	12.38	0.38	+13.25	87.0
P_{11}	12.38	0.38	-13.25	87.0
P_{12}	12.38	0.38	-39.75	87.0
P_{13}	10.18	0.32	-53.00	100.0
P_{14}	7.92	0.25	-53.00	121.2
P_{15}	9.36	0.29	-53.00	147.2
P_{16}	8.64	0.27	-53.00	178.0
TOTAL	148.6	4.62	0	129.4

Figure 19 (continued)



STATION 362

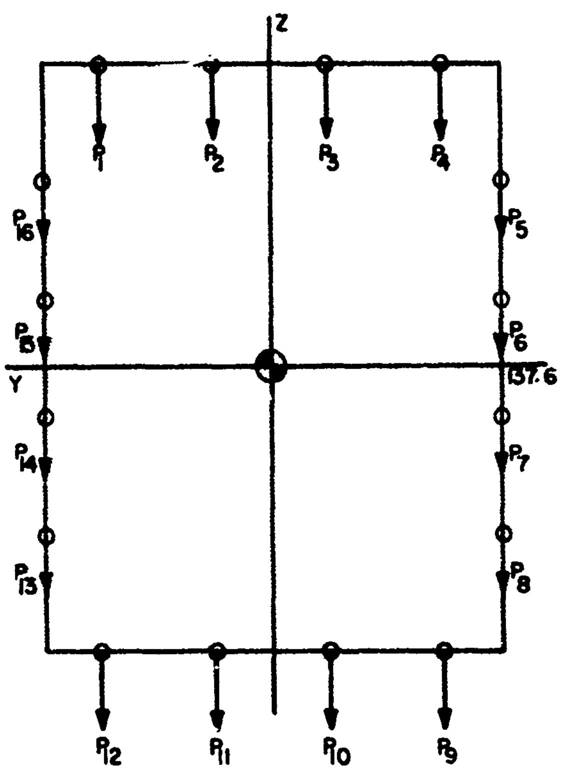


STATION 382

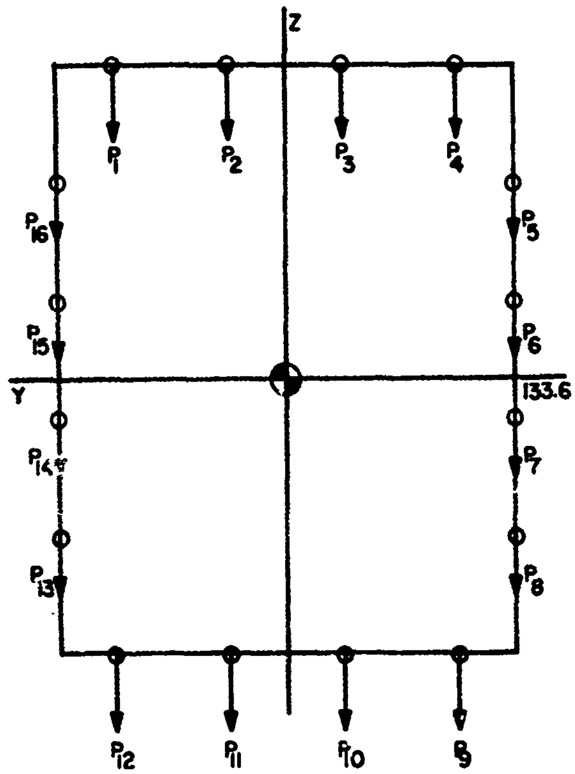
NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	22.74	0.71	-39.75	191.0
P_2	22.74	0.71	-13.25	191.0
P_3	22.74	0.71	+13.25	191.0
P_4	22.74	0.71	+39.75	191.0
P_5	31.57	0.98	+53.00	172.5
P_6	7.12	0.22	+53.00	143.7
P_7	9.08	0.28	+53.00	128.7
P_8	11.54	0.36	+53.00	100.0
P_9	9.71	0.30	+39.75	87.0
P_{10}	9.71	0.30	+13.25	87.0
P_{11}	9.71	0.30	-13.25	87.0
P_{12}	9.71	0.30	-39.75	87.0
P_{13}	11.54	0.36	-53.00	100.0
P_{14}	9.08	0.28	-53.00	128.7
P_{15}	7.12	0.22	-53.00	143.7
P_{16}	31.57	0.98	-53.00	172.5
TOTAL	248.4	7.72	0	153.9

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	6.90	0.21	-39.75	191.0
P_2	6.90	0.21	-13.25	191.0
P_3	6.90	0.21	+13.25	191.0
P_4	6.90	0.21	+39.75	191.0
P_5	11.42	0.35	+53.00	178.0
P_6	9.08	0.28	+53.00	148.4
P_7	7.14	0.22	+53.00	122.4
P_8	14.87	0.46	+53.00	100.0
P_9	10.64	0.33	+39.75	87.0
P_{10}	10.64	0.33	+13.25	87.0
P_{11}	10.64	0.33	-13.25	87.0
P_{12}	10.64	0.33	-39.75	87.0
P_{13}	14.87	0.46	-53.00	100.0
P_{14}	7.14	0.22	-53.00	122.4
P_{15}	9.08	0.28	-53.00	148.4
P_{16}	11.42	0.35	-53.00	178.0
TOTAL	155.2	4.82	0	131.8

Figure 19 (continued)



STATION 402

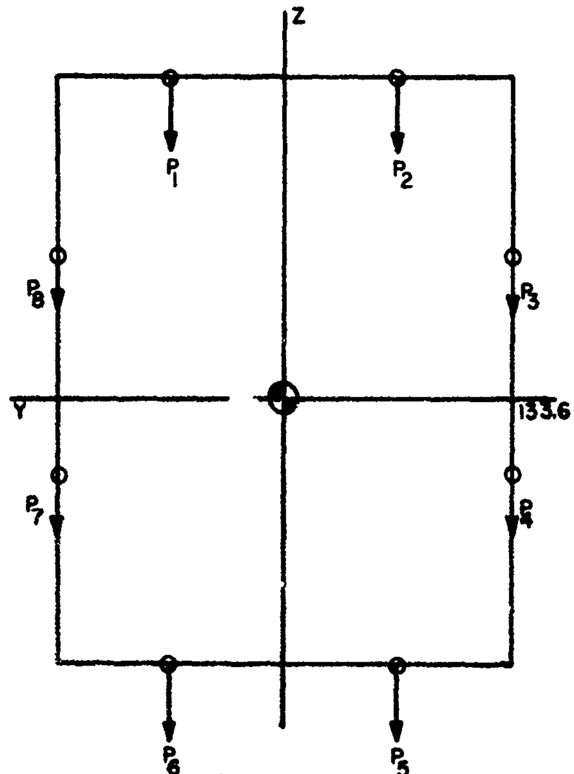


STATION 422

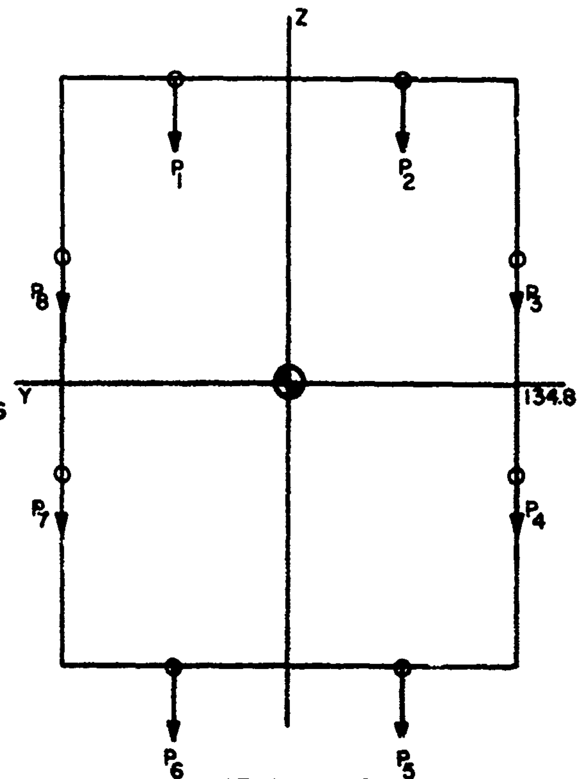
NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	5.76	0.18	-39.75	191.0
P_2	5.76	0.18	-13.25	191.0
P_3	5.76	0.18	+13.25	191.0
P_4	5.76	0.18	+39.75	191.0
P_5	7.15	0.22	+53.00	178.0
P_6	5.97	0.19	+53.00	151.3
P_7	6.24	0.19	+53.00	125.3
P_8	6.32	0.20	+53.00	100.0
P_9	6.65	0.21	+39.75	87.0
P_{10}	6.65	0.21	+13.25	87.0
P_{11}	6.65	0.21	-13.25	87.0
P_{12}	6.65	0.21	-39.75	87.0
P_{13}	6.32	0.20	-53.00	100.0
P_{14}	6.24	0.19	-53.00	125.3
P_{15}	5.97	0.19	-53.00	151.3
P_{16}	7.15	0.22	-53.00	178.0
TOTAL	101.0	3.14	0	137.6

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	5.17	0.16	-39.75	191.0
P_2	5.17	0.16	-13.25	191.0
P_3	5.17	0.16	+13.25	191.0
P_4	5.17	0.16	+39.75	191.0
P_5	6.36	0.20	+53.00	178.0
P_6	6.20	0.19	+53.00	149.3
P_7	5.71	0.18	+53.00	123.3
P_8	6.93	0.22	+53.00	100.0
P_9	7.33	0.23	+39.75	87.0
P_{10}	7.33	0.23	+13.25	87.0
P_{11}	7.33	0.23	-13.25	87.0
P_{12}	7.33	0.23	-39.75	87.0
P_{13}	6.93	0.22	-53.00	100.0
P_{14}	5.71	0.18	-53.00	123.3
P_{15}	6.20	0.19	-53.00	149.3
P_{16}	6.36	0.20	-53.00	178.0
TOTAL	100.4	3.12	0	133.6

Figure 19 (continued)



STATION 442

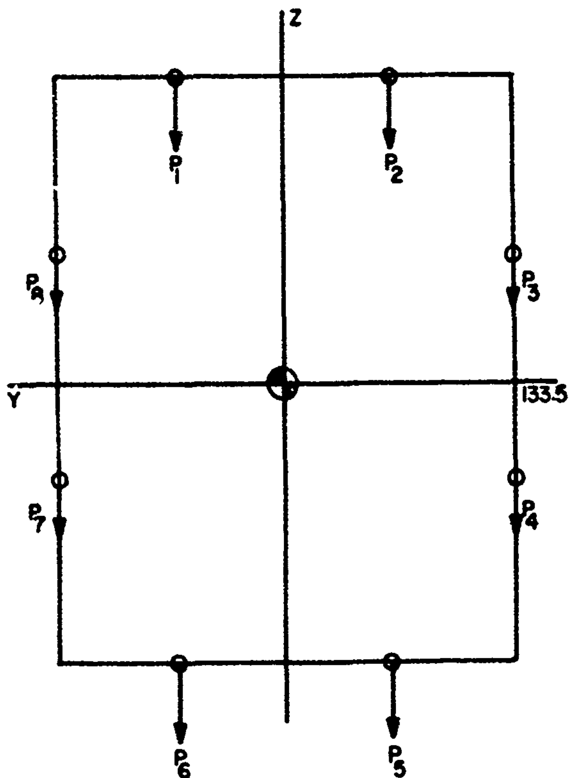


STATION 482

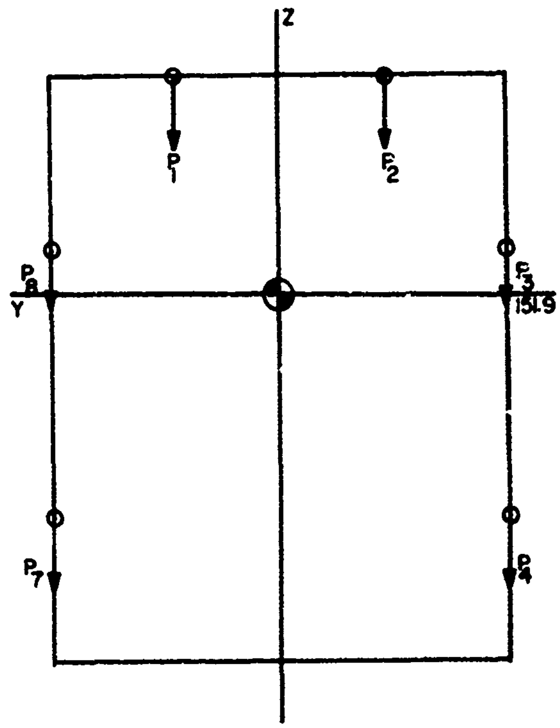
NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	23.38	.73	-20	191
P_2	23.38	.73	+20	191
P_3	46.83	1.45	+53	157
P_4	53.28	1.65	+53	121
P_5	37.86	1.18	+20	87
P_6	37.86	1.18	-20	87
P_7	53.28	1.65	-53	121
P_8	46.83	1.45	-53	157
TOTAL	322.7	10.02	0	133.6

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	24.32	.76	-20	191
P_2	24.32	.76	+20	191
P_3	21.58	.67	+53	157
P_4	14.65	.45	+53	121
P_5	34.40	1.07	+20	87
P_6	34.40	1.07	-20	87
P_7	14.65	.45	-53	121
P_8	21.58	.67	-53	157
TOTAL	189.9	5.9	0	134.8

Figure 19 (continued)



STATION 522



STATION 567

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	13.53	.42	-20	191
P_2	13.53	.42	+20	191
P_3	14.25	.44	+53	157
P_4	13.04	.40	+53	121
P_5	20.43	.63	+20	87
P_6	20.43	.63	-20	87
P_7	13.04	.40	-53	121
P_8	14.25	.44	-53	157
TOTAL	122.5	3.78	0	133.5

NODE	WEIGHT LBS	MASS SLUGS	Y - BL IN	Z - W.L. IN
P_1	23.58	.73	-20	191
P_2	23.58	.73	+20	191
P_3	54.49	1.69	+53	157
P_4	38.83	1.21	+53	121
P_5	0	0	-	-
P_6	0	0	-	-
P_7	38.83	1.21	-53	121
P_8	54.49	1.69	-53	157
TOTAL	233.8	7.26	0	151.9

Figure 19 (continued)

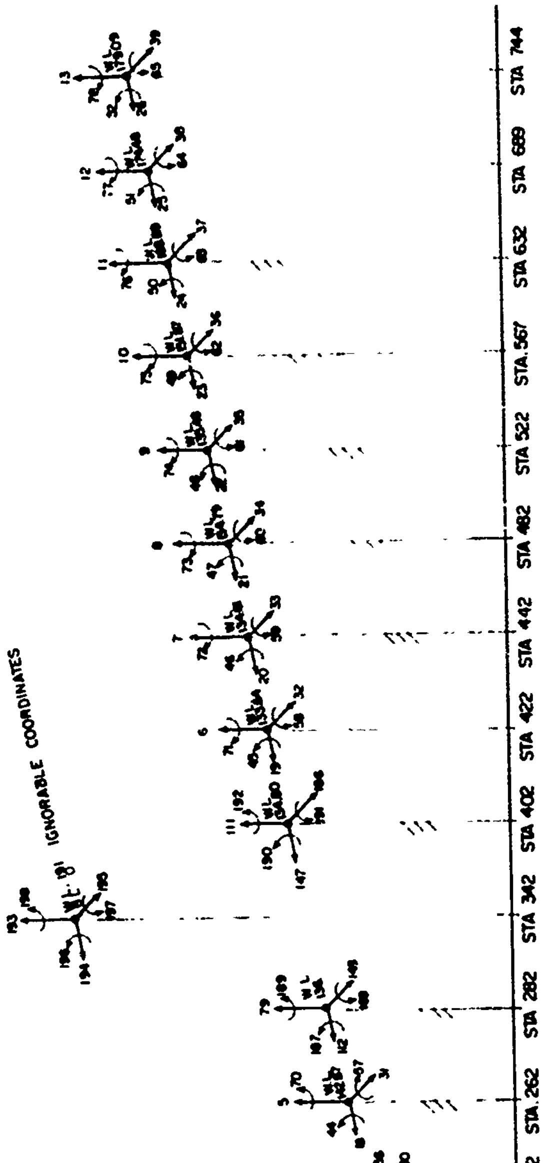


Figure 20 Six Bay Original Degree of Freedom Model
Beam Degrees of Freedom

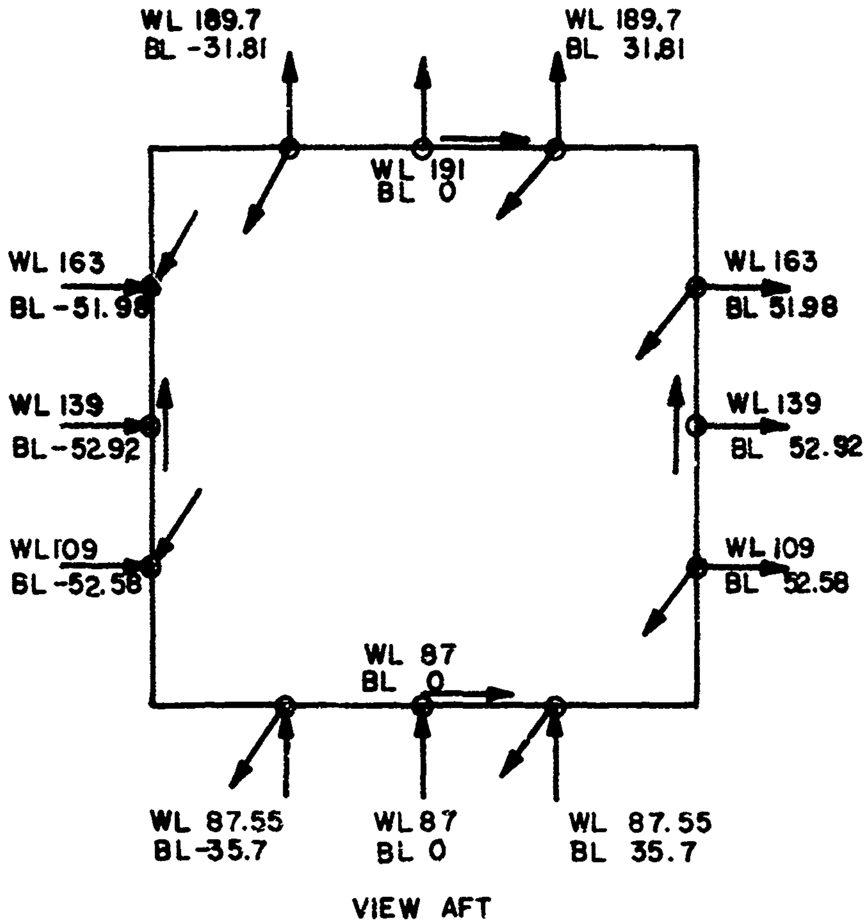


Figure 21 Frame Degree of Freedom Allocations, FS 302-382

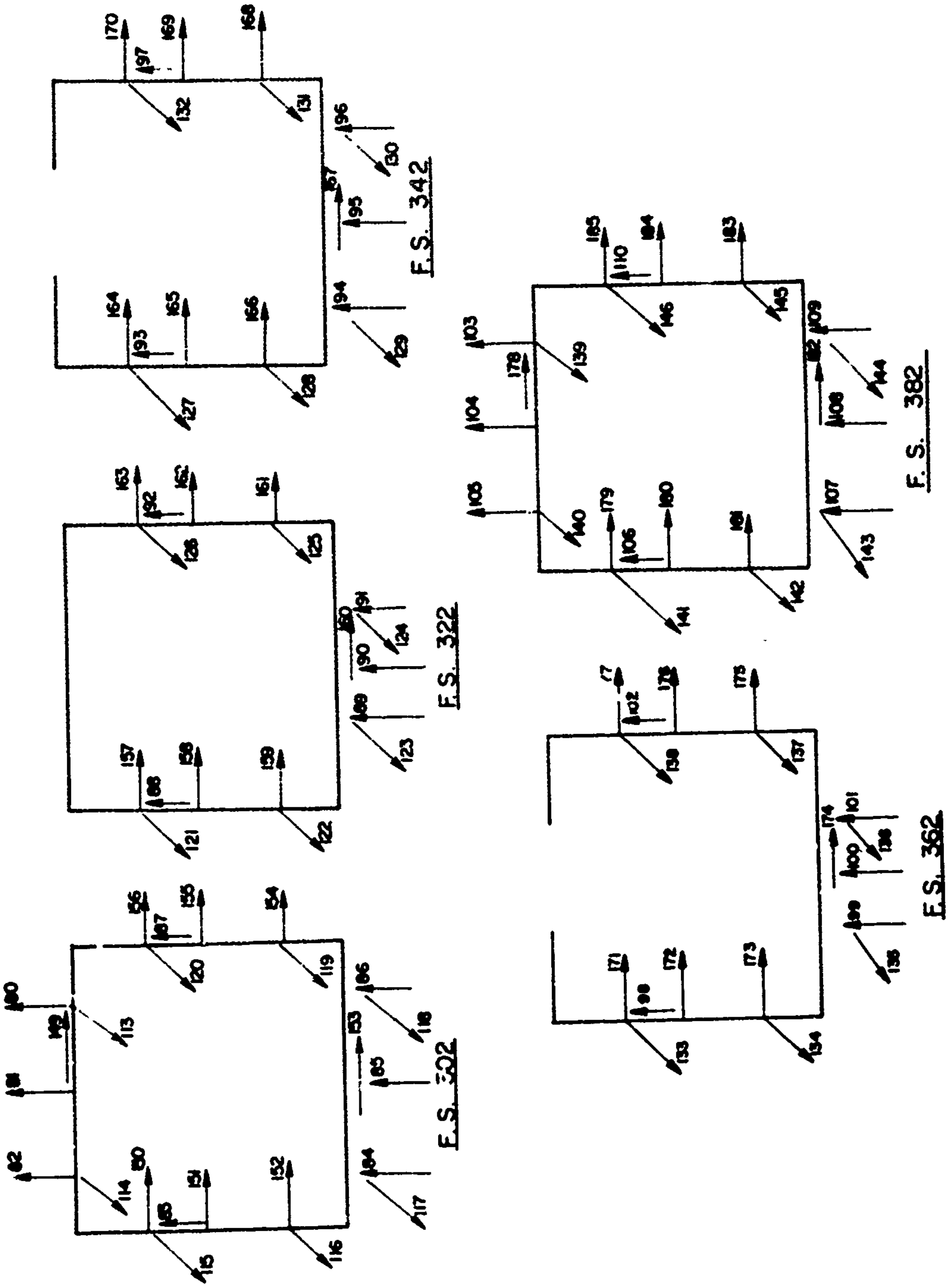


Figure 22 Six Bay Original Degree of Freedom Model Flexible Frame Degree of Freedom Allocations (Looking Aft)

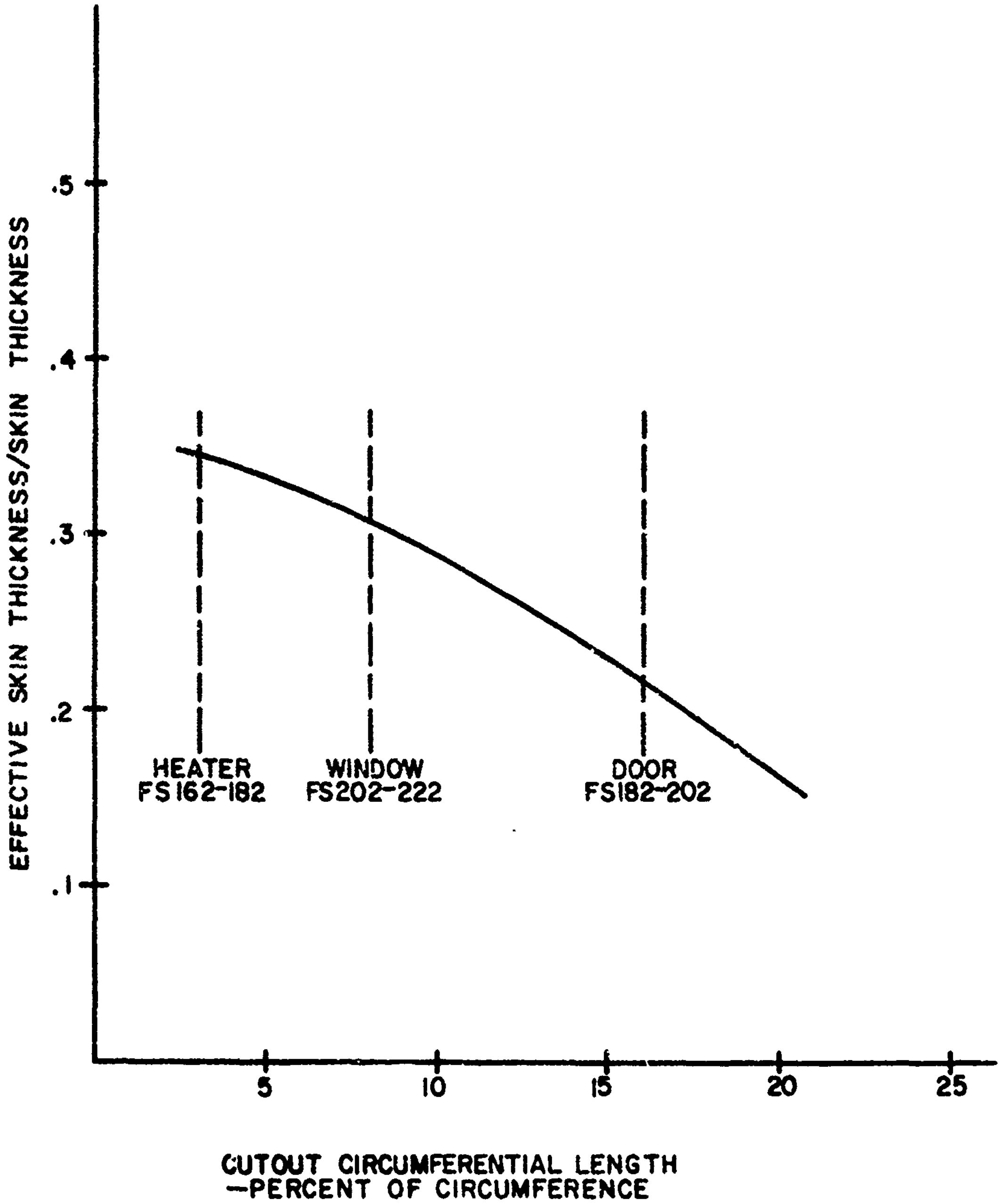


Figure 23 Effective Skin Thickness for Isolated Cutouts in Sections under Torsion

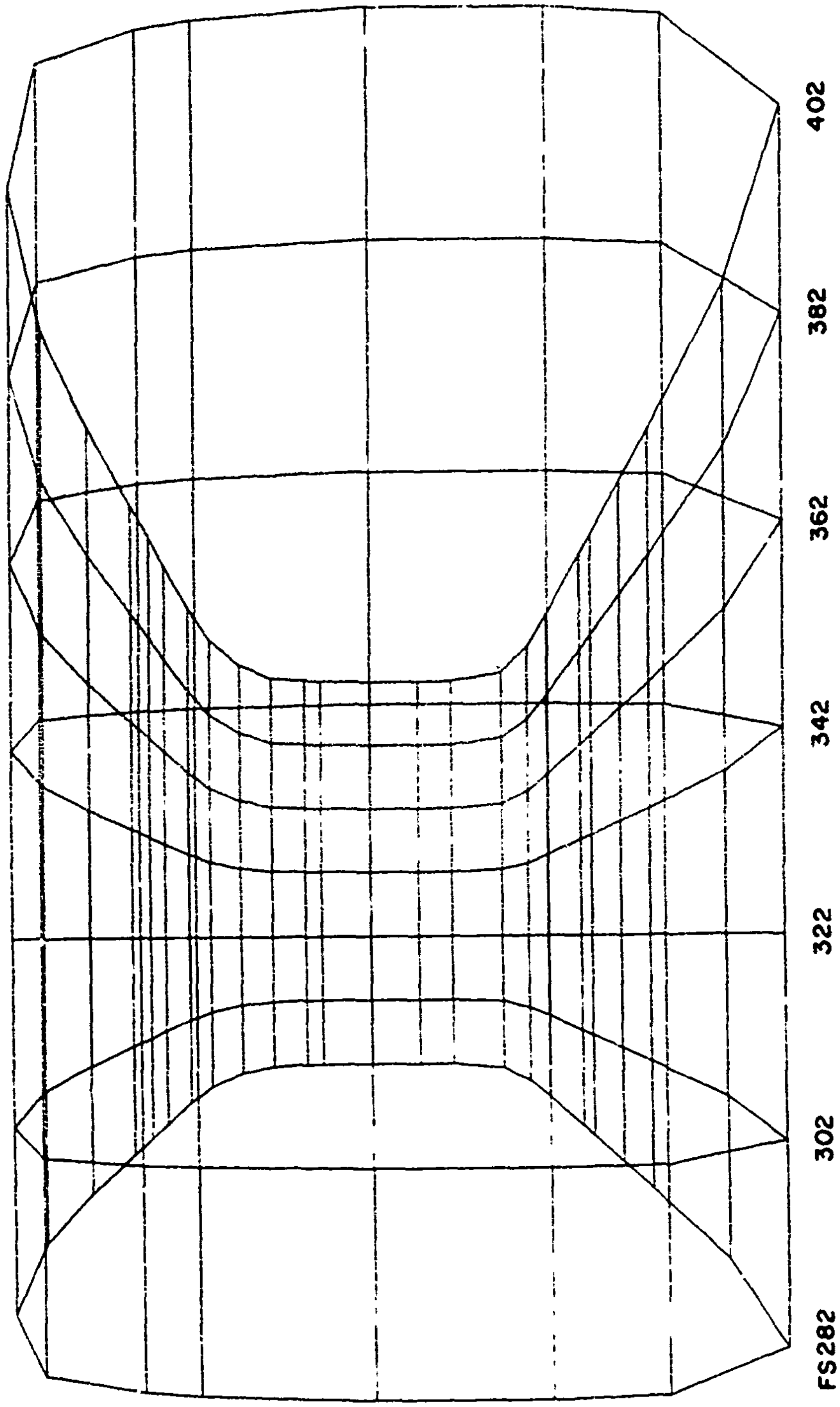


Figure 24 Six Bay, Thirty Stringer Finite Element Model, FS 282-402

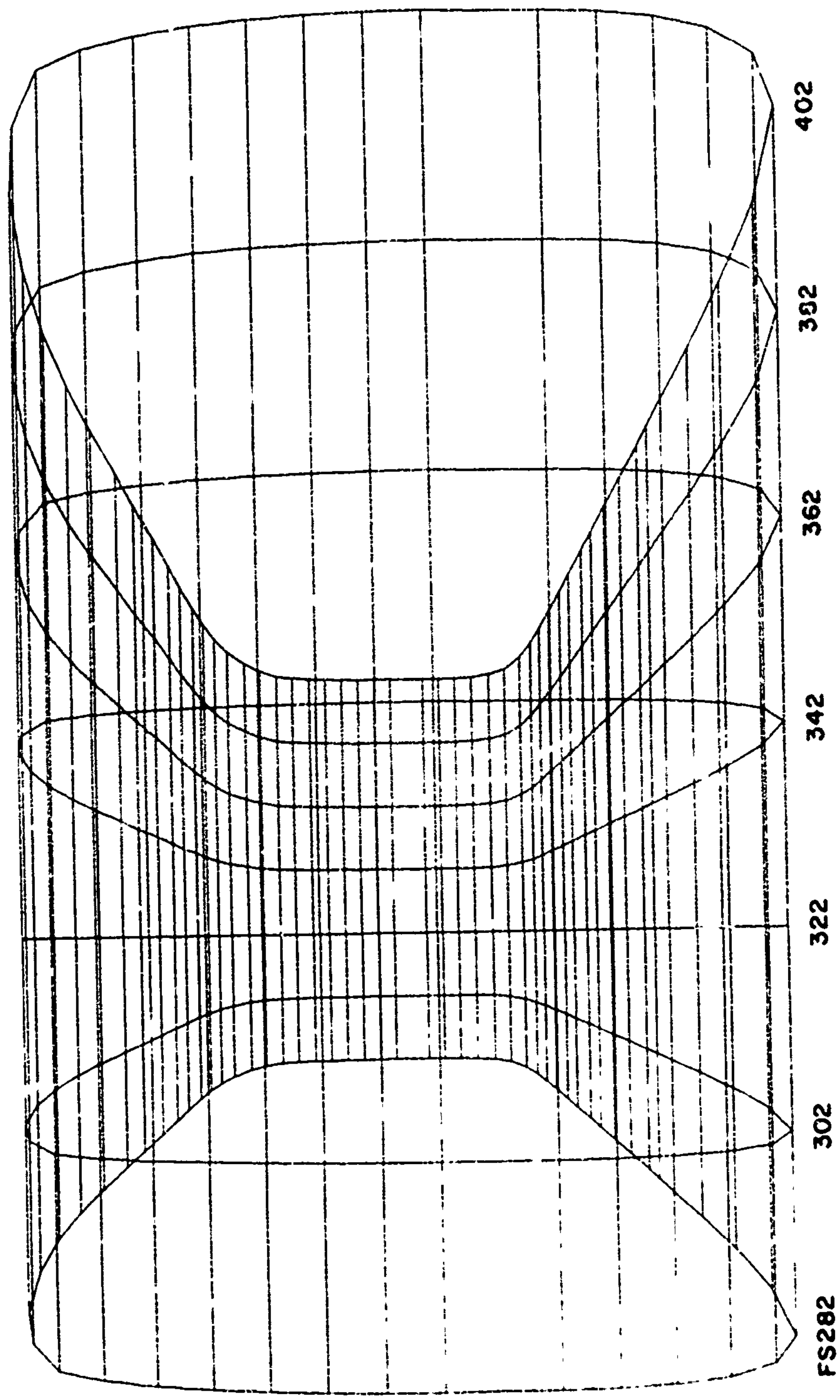


Figure 25 Six Bay, Sixty Stringer Finite Element Model, FS 282-402

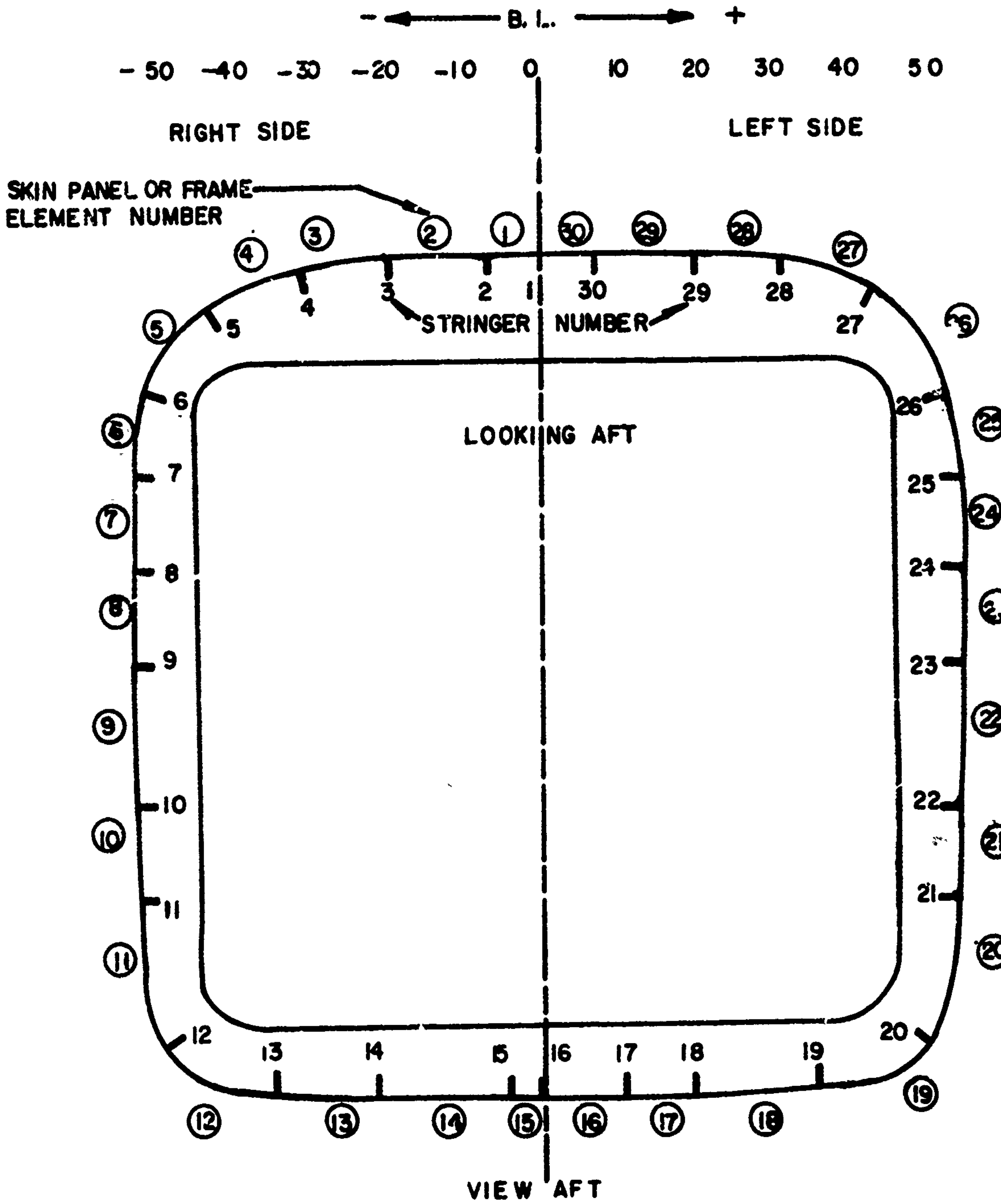
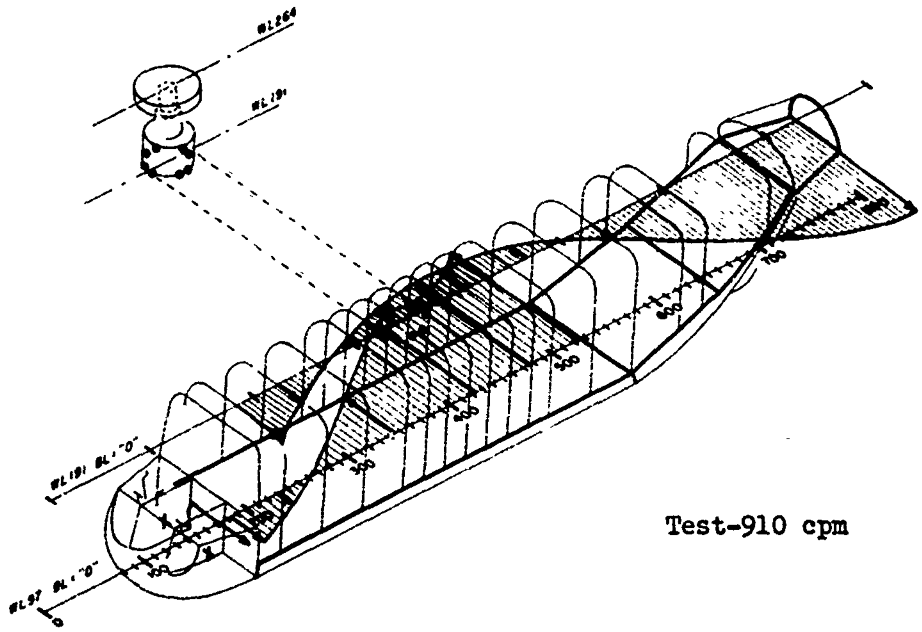
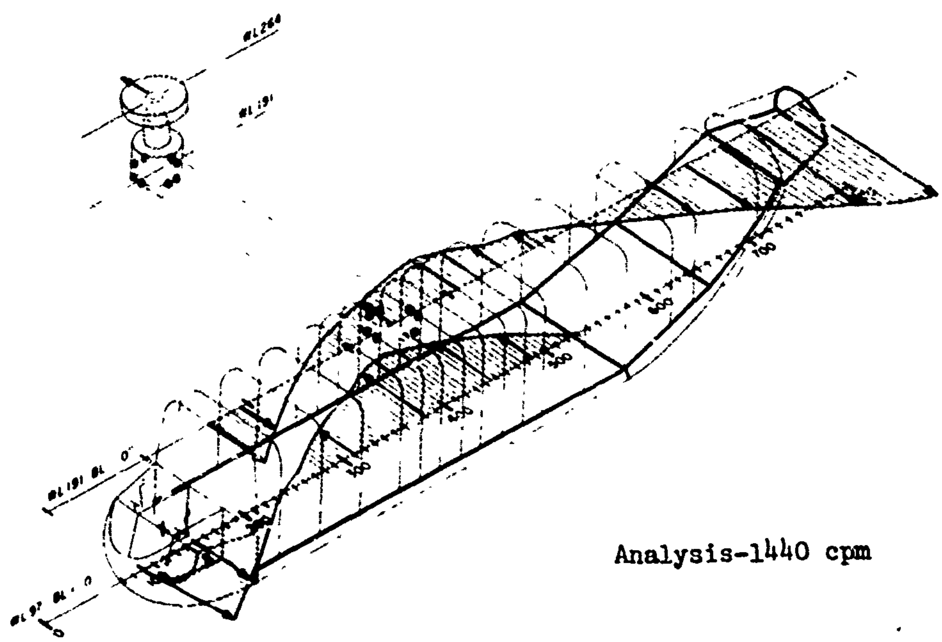


Figure 26 Thirty Stringer Model, Stringer Panel and Frame Element Locations

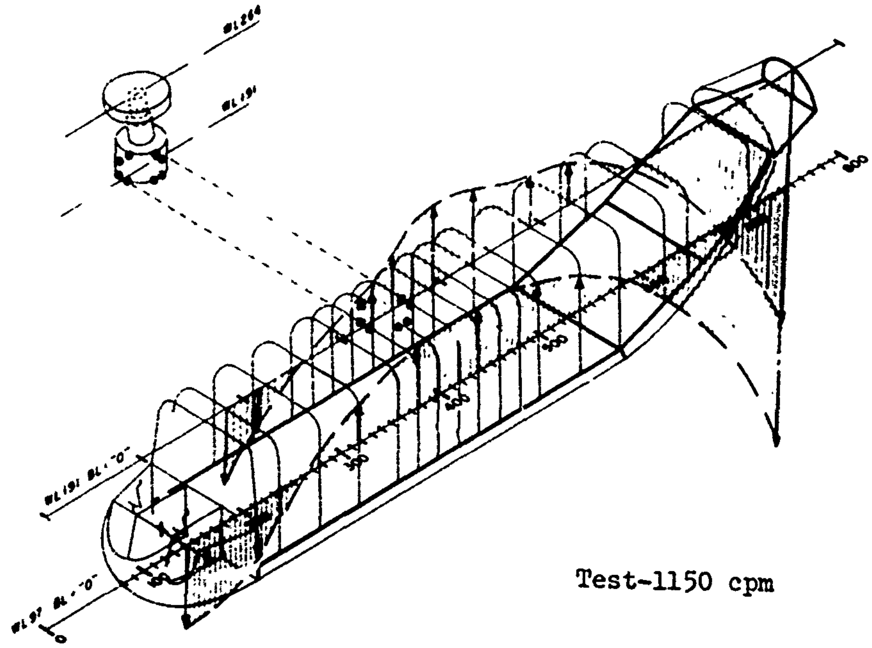


Test-910 cpm

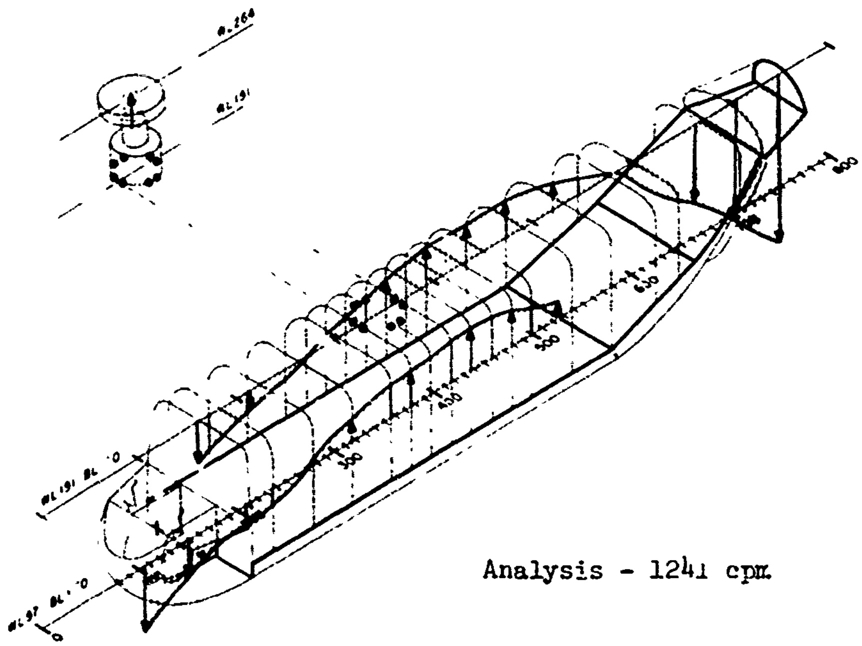


Analysis-1440 cpm

Figure 27 Phase I Correlation of First Lateral Bending Mode - 6 Bay

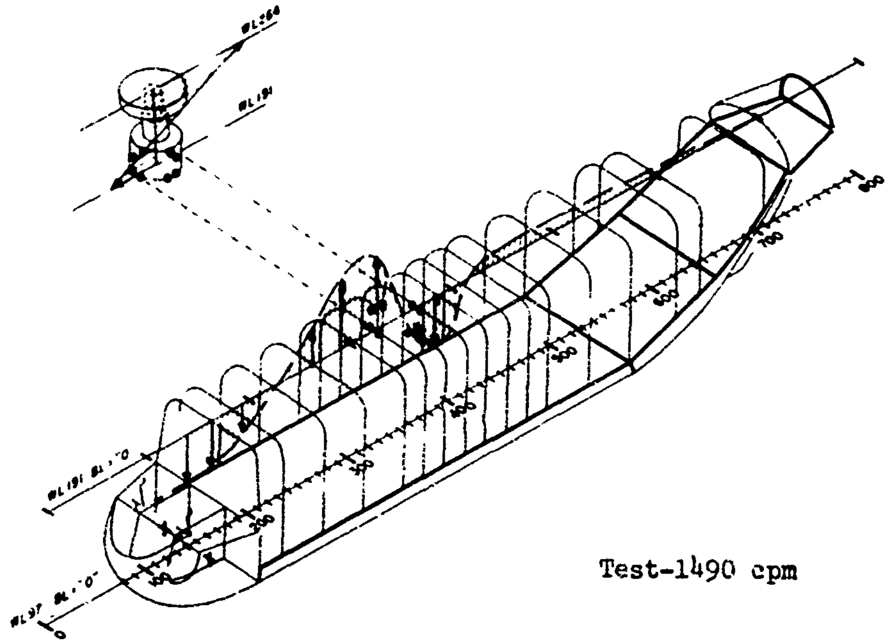


Test-1150 cpm

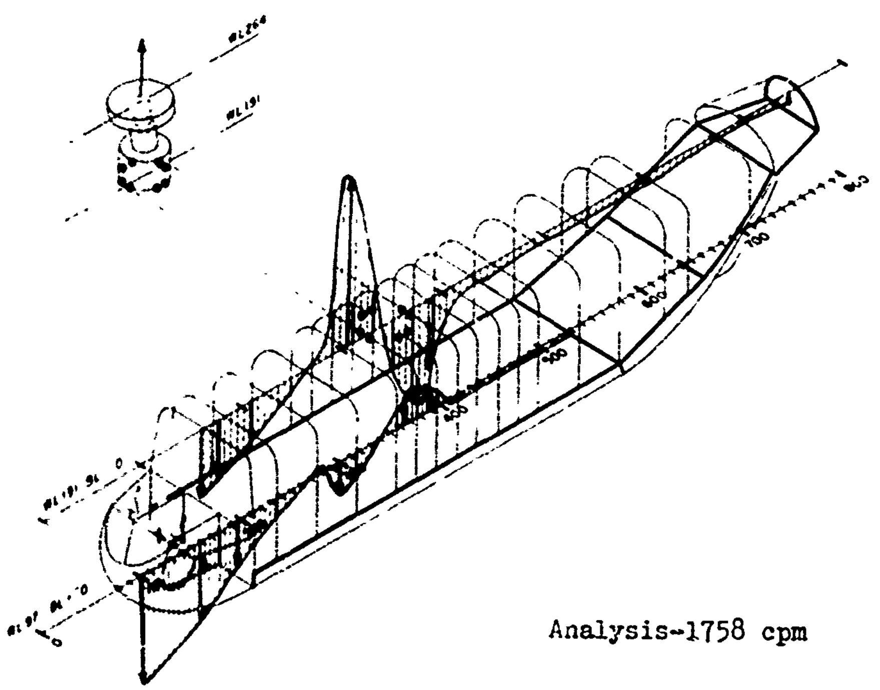


Analysis - 1241 cpm

Figure 28 Phase I Correlation of First Vertical Bending Mode - 6 Bay

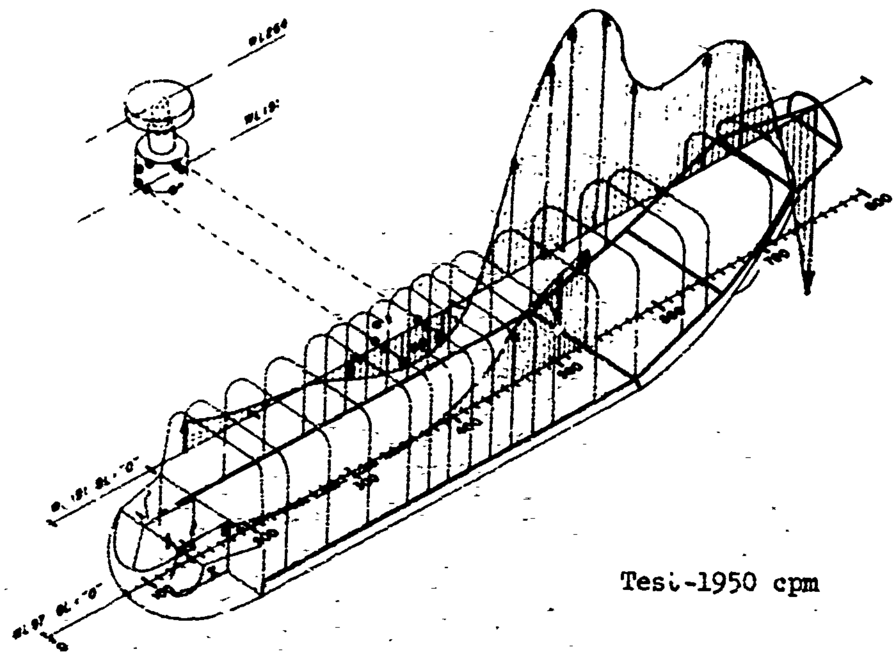


Test-1490 cpm

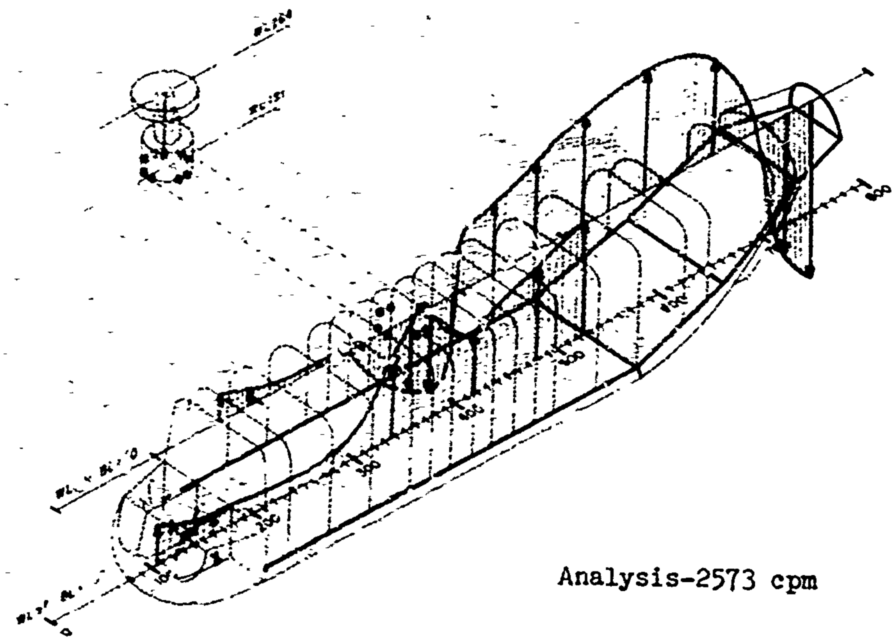


Analysis-1758 cpm

Figure 29 Phase I Correlation of Transmission Pitch Mode - 6 Bay



Test-1950 cpm



Analysis-2573 cpm

Figure 30 Phase 1 Correlation of Second Vertical Bending Mode - 6 Bay

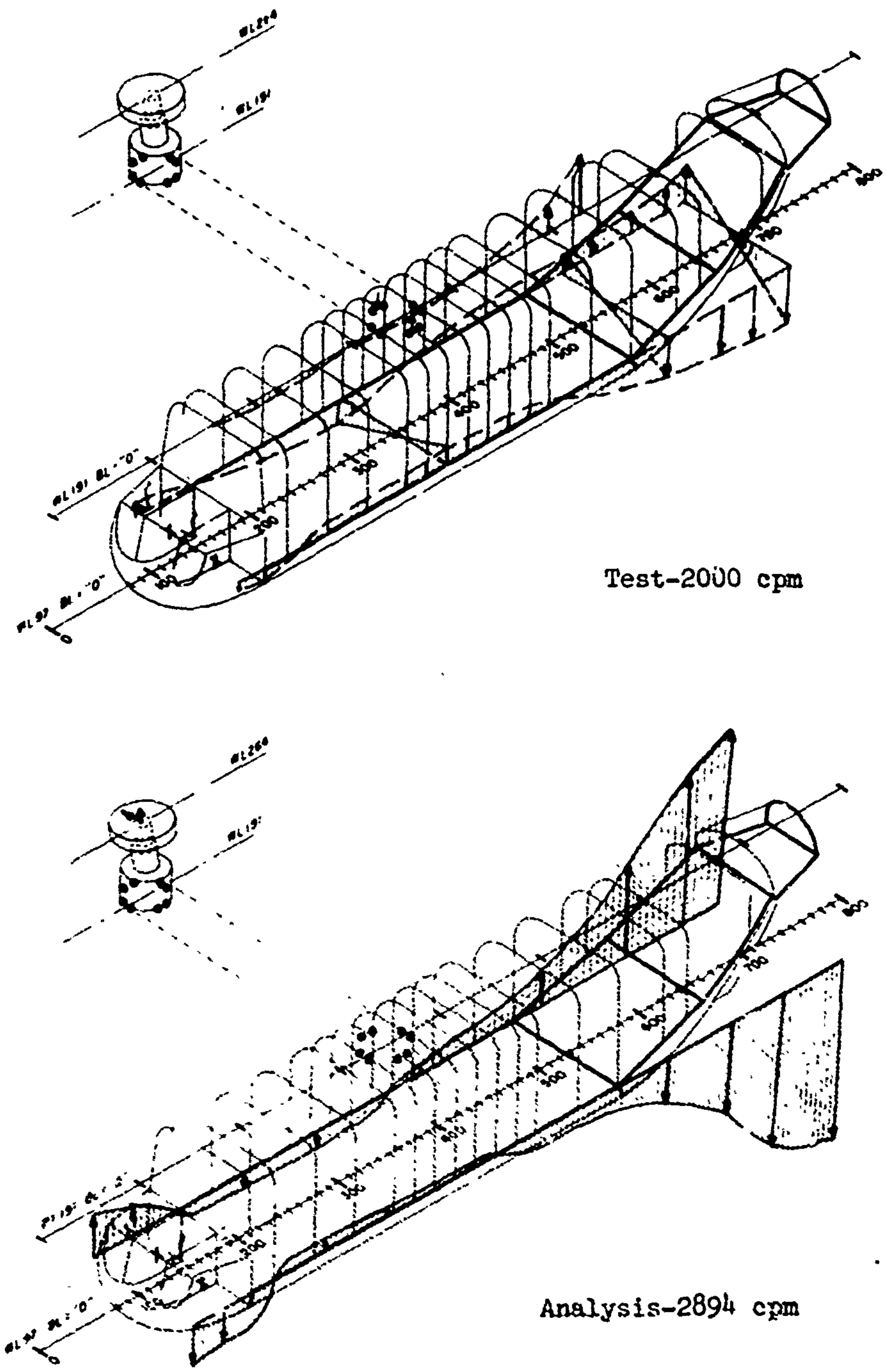


Figure 31 Phase I Correlation of Transmission Roll Mode - 6 Bay

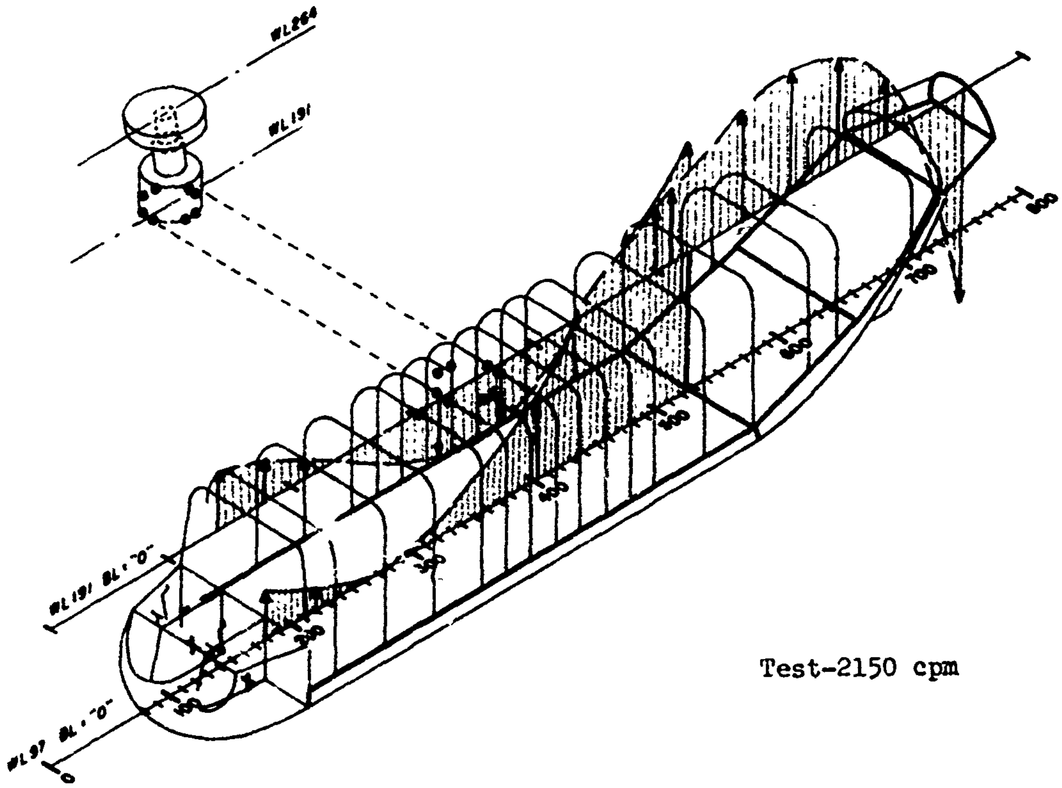
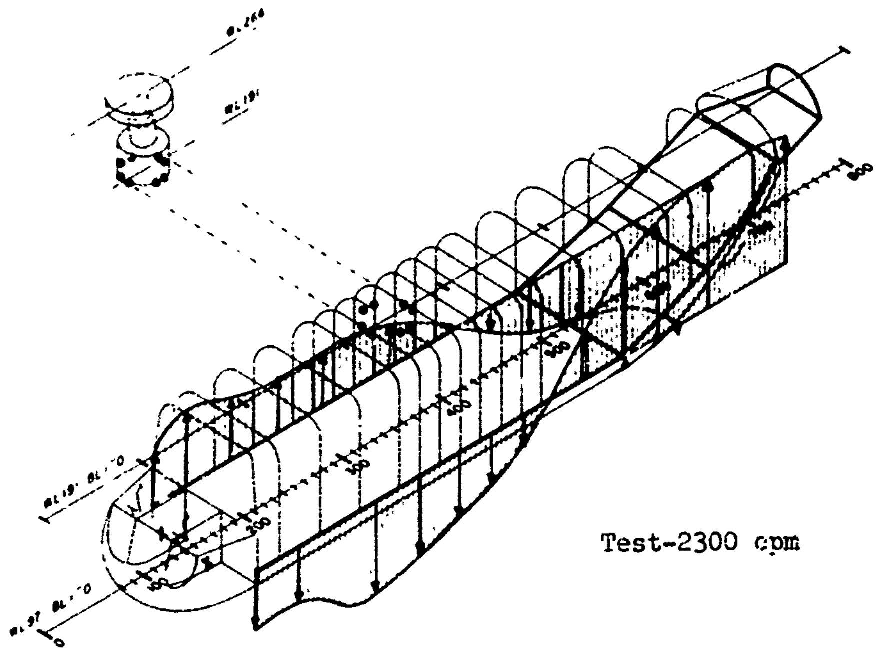


Figure 32 Phase I Transmission Vertical Mode - 6 Bay



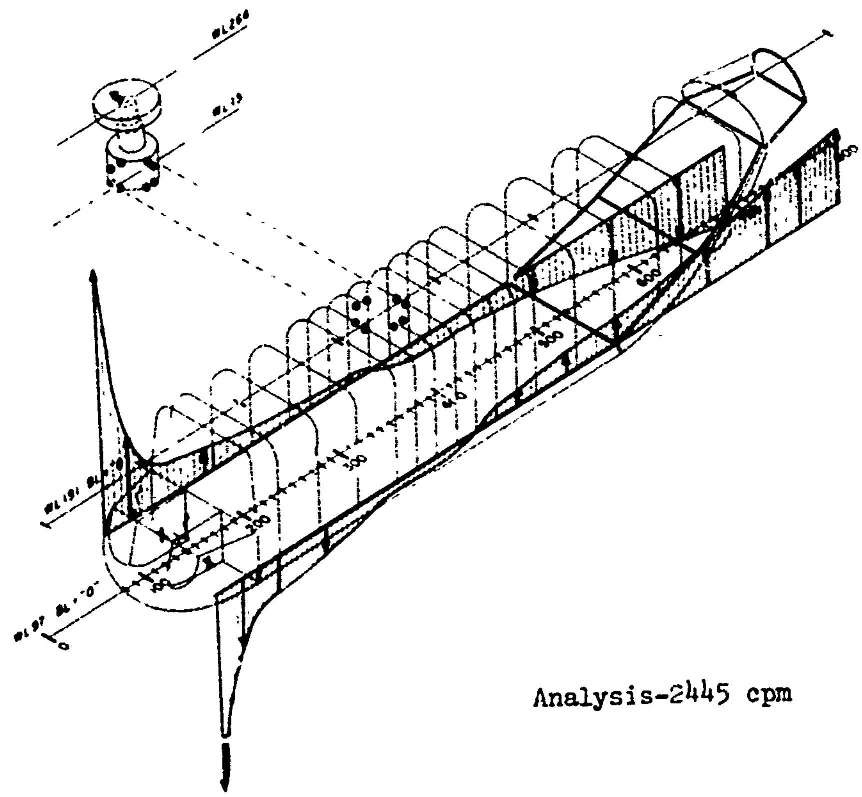


Figure 33 Phase I Correlation of Torsion Mode - 6 Bay

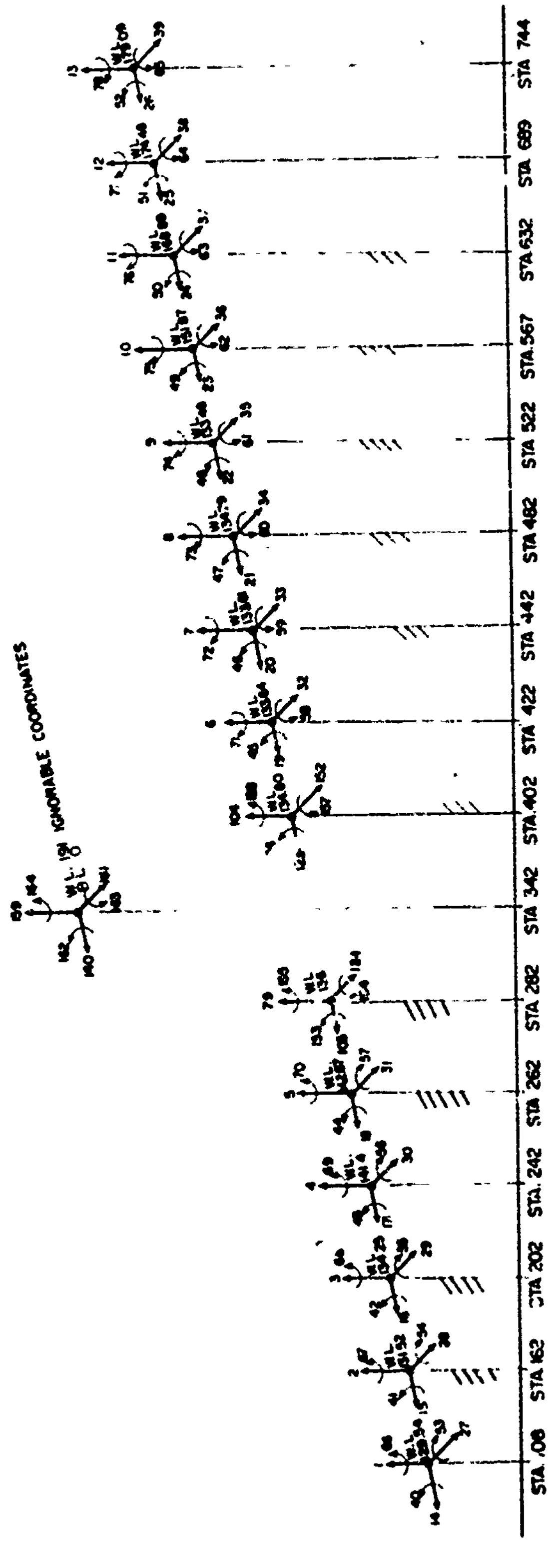


Figure 34 Six Bay Reduced Degree of Freedom Model
Beam Degrees of Freedom

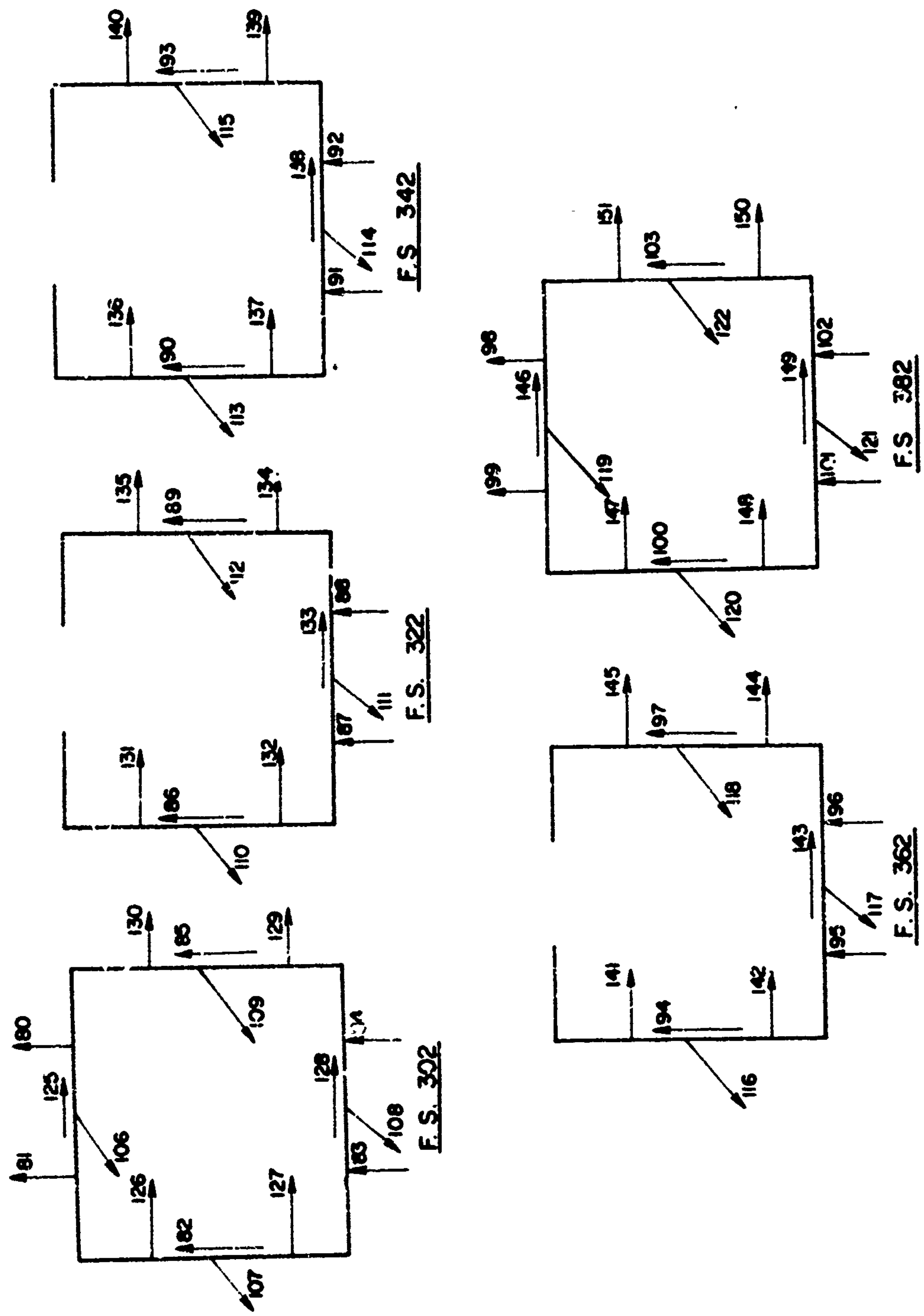


Figure 35 Six Bay Reduced Degree of Freedom Model
Flexible Frame Degree of Freedom Allocations (Looking Aft)

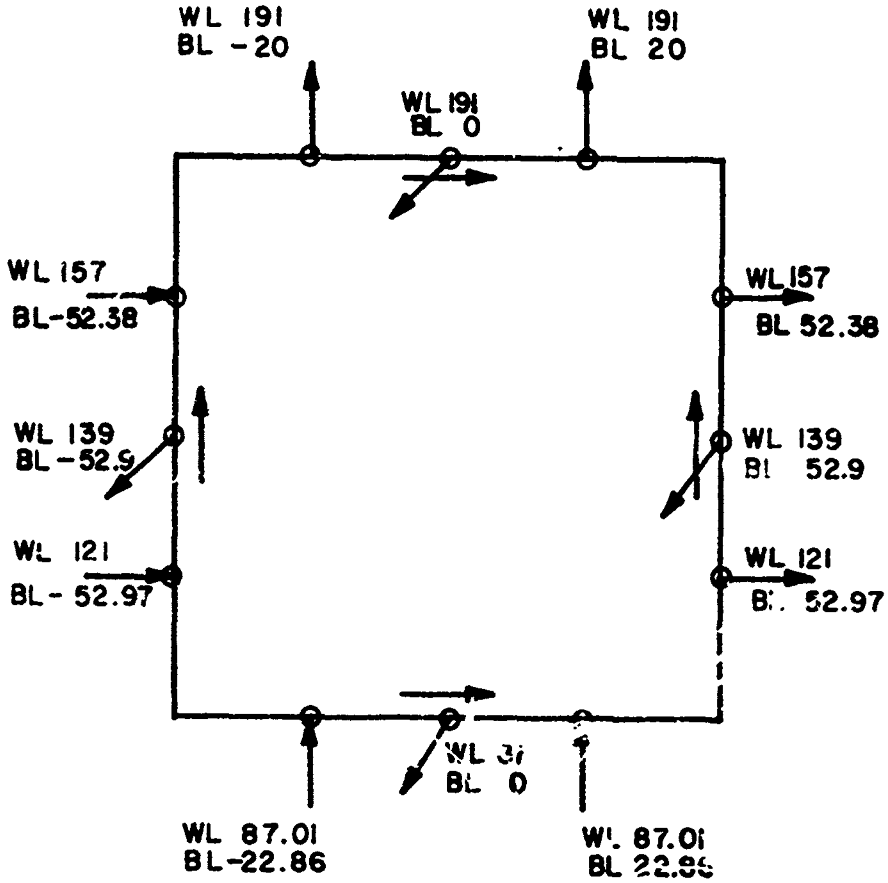


Figure 36 Degree of Freedom Locations for Reduced Degree of Freedom Models (View Aft)

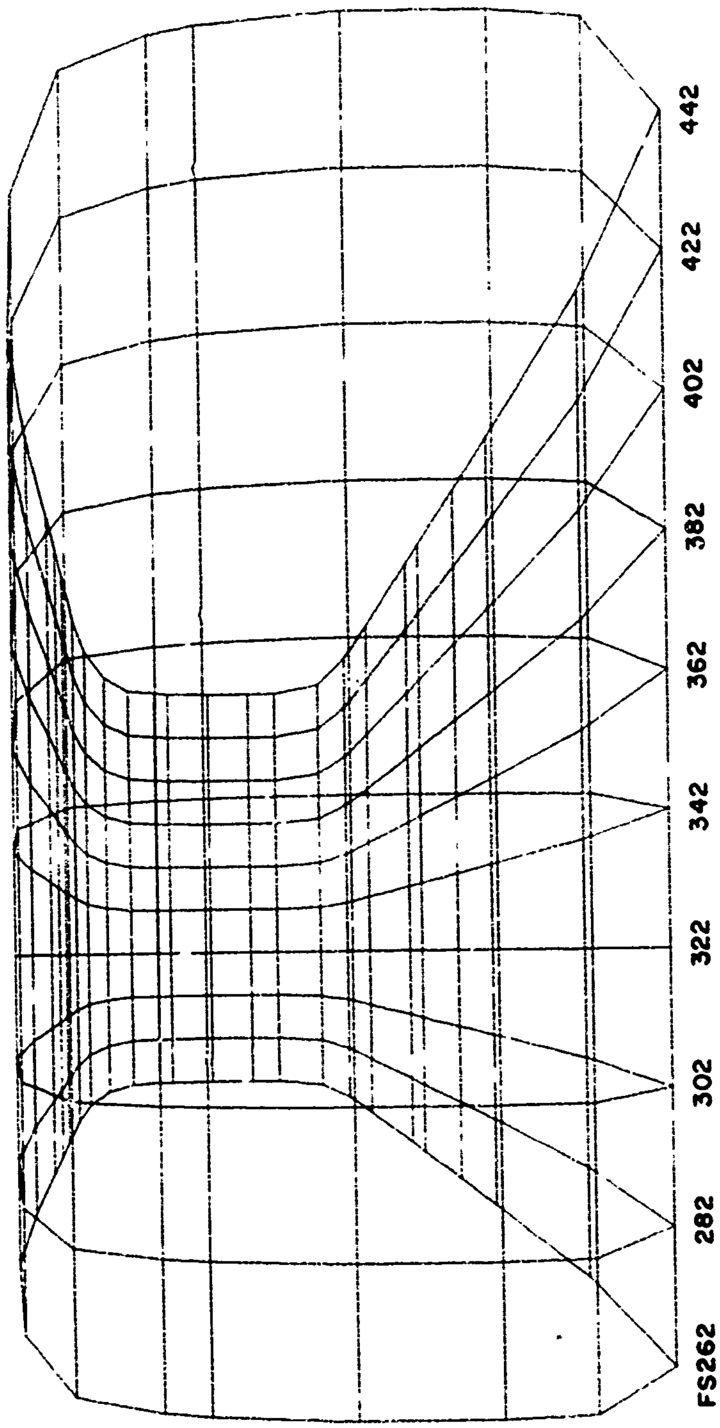


Figure 37 Mine Bay, Thirty Stringer Finite Element Model, FS 262-442

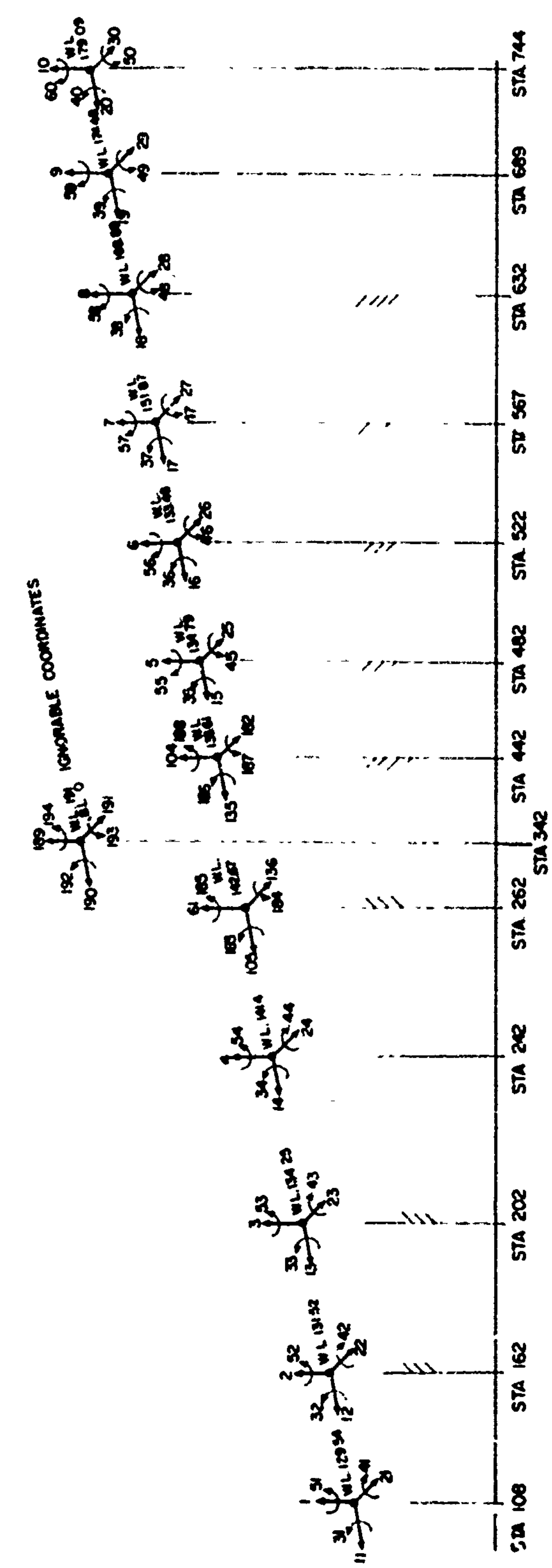


Figure 38 Nine Bay Reduced Degree of Freedom Model Beam Degrees of Freedom

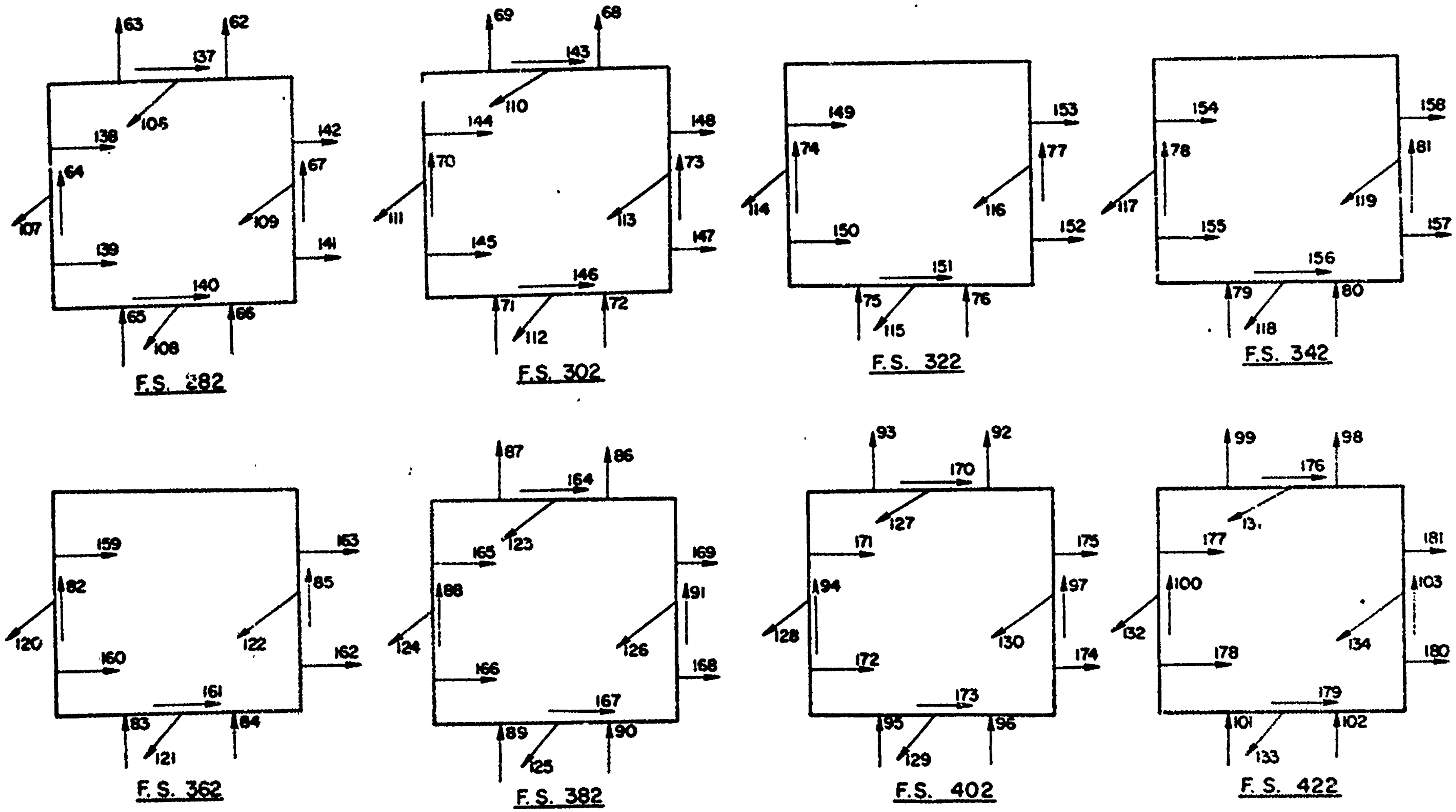


Figure 39 Nine Bay Reduced Degree of Freedom Model
Flexible Frame Degree of Freedom Allocations (Looking Aft)

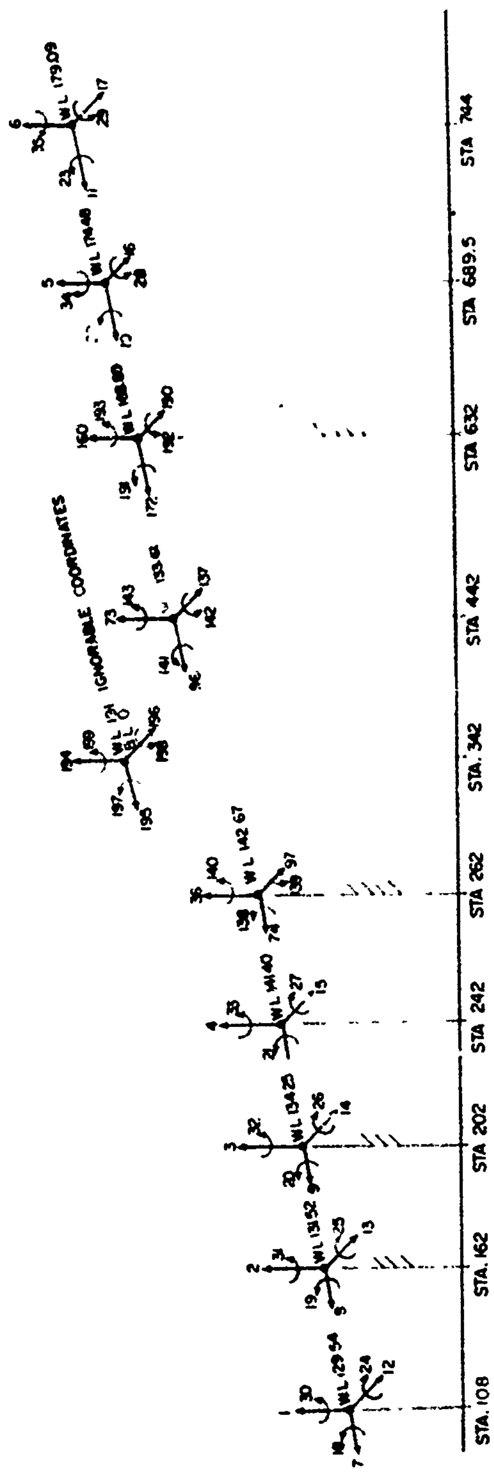


Figure 40 Eighteen bay Model - Phase I Beam Degrees of Freedom

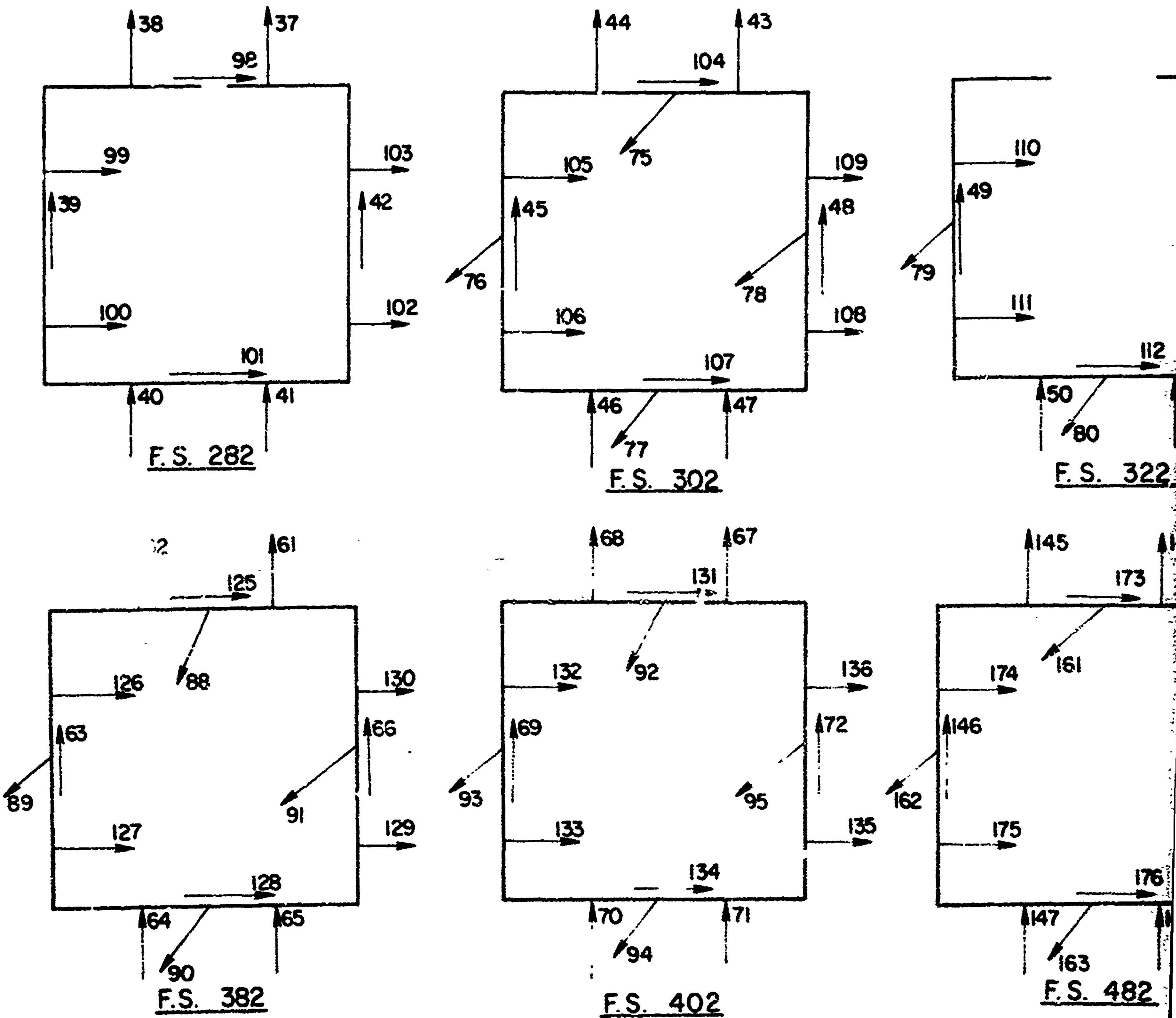
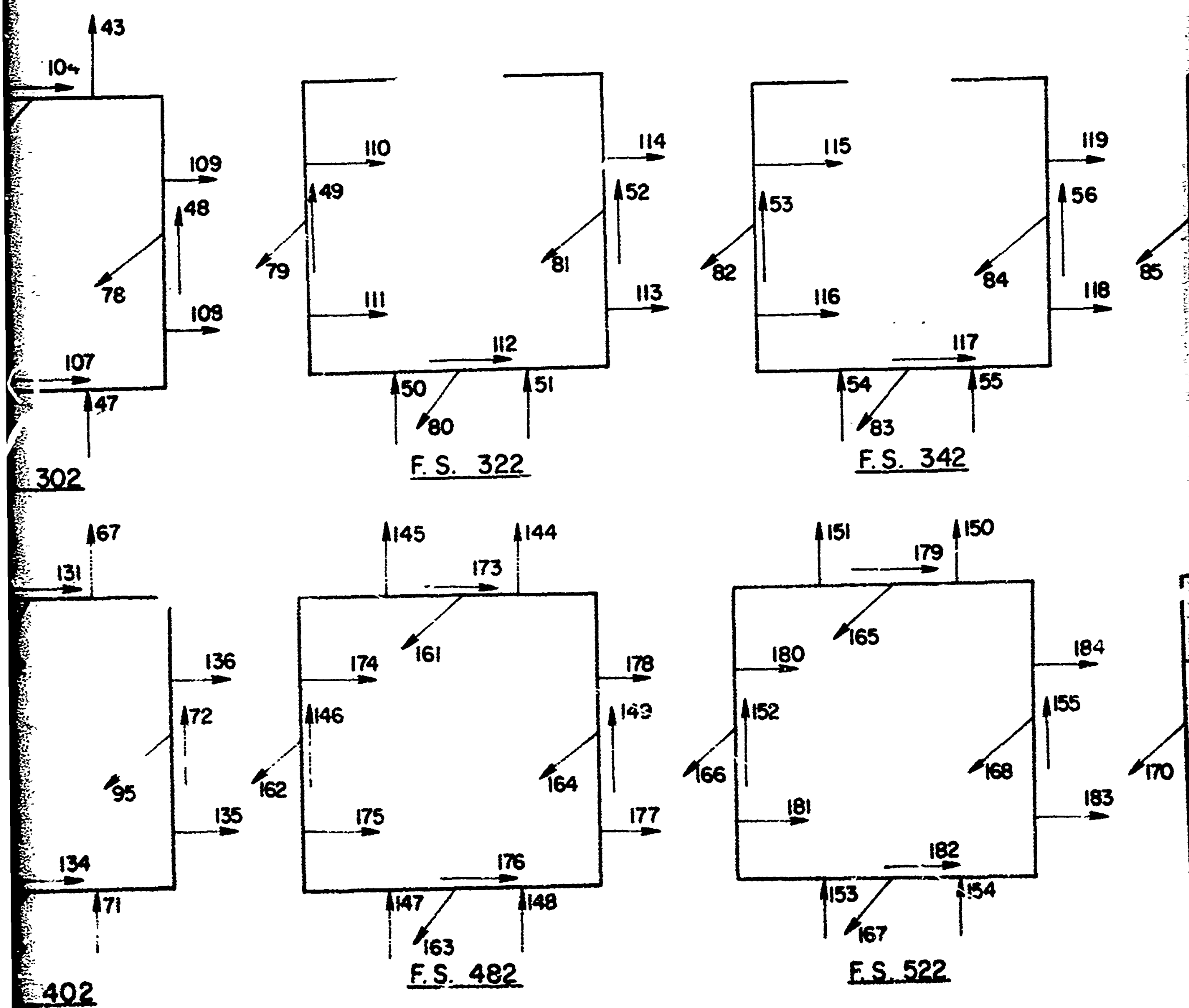


Figure 41 Eighteen Bay Model Phase I
Flexible Frame Degree of Fr.edom Al.ocations (Looking Aft)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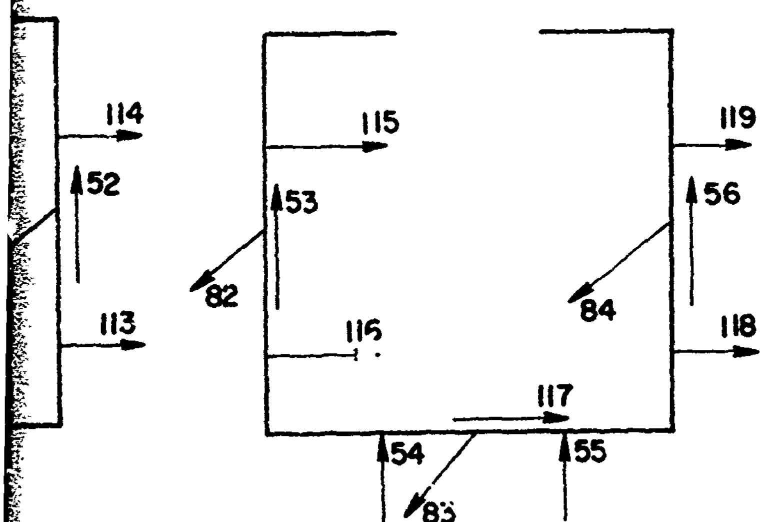
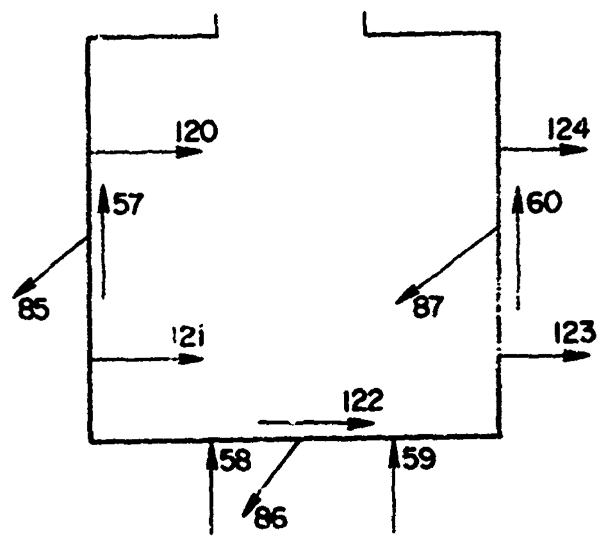
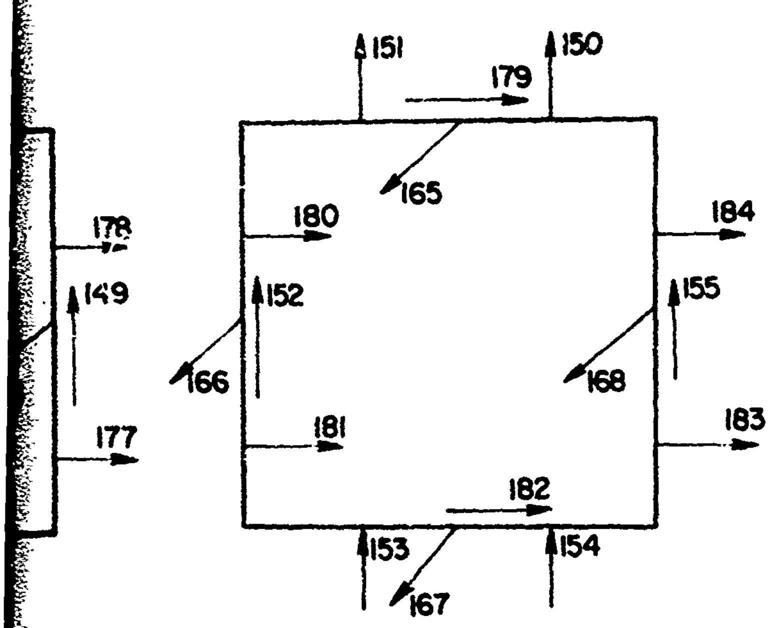
(Looking Aft)



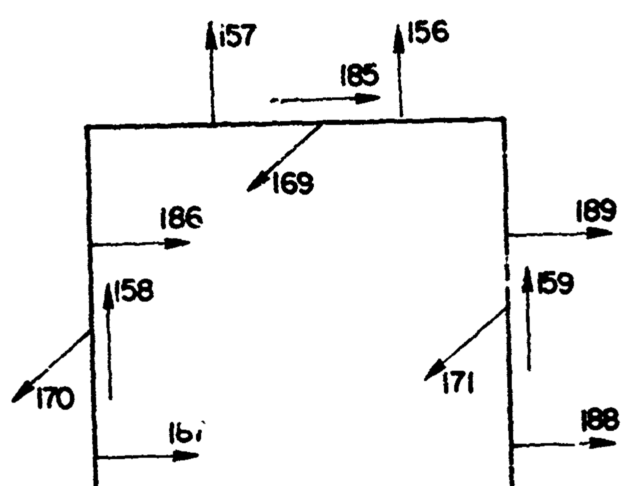
F.S. 342



F.S. 362



F.S. 522



F.S. 567

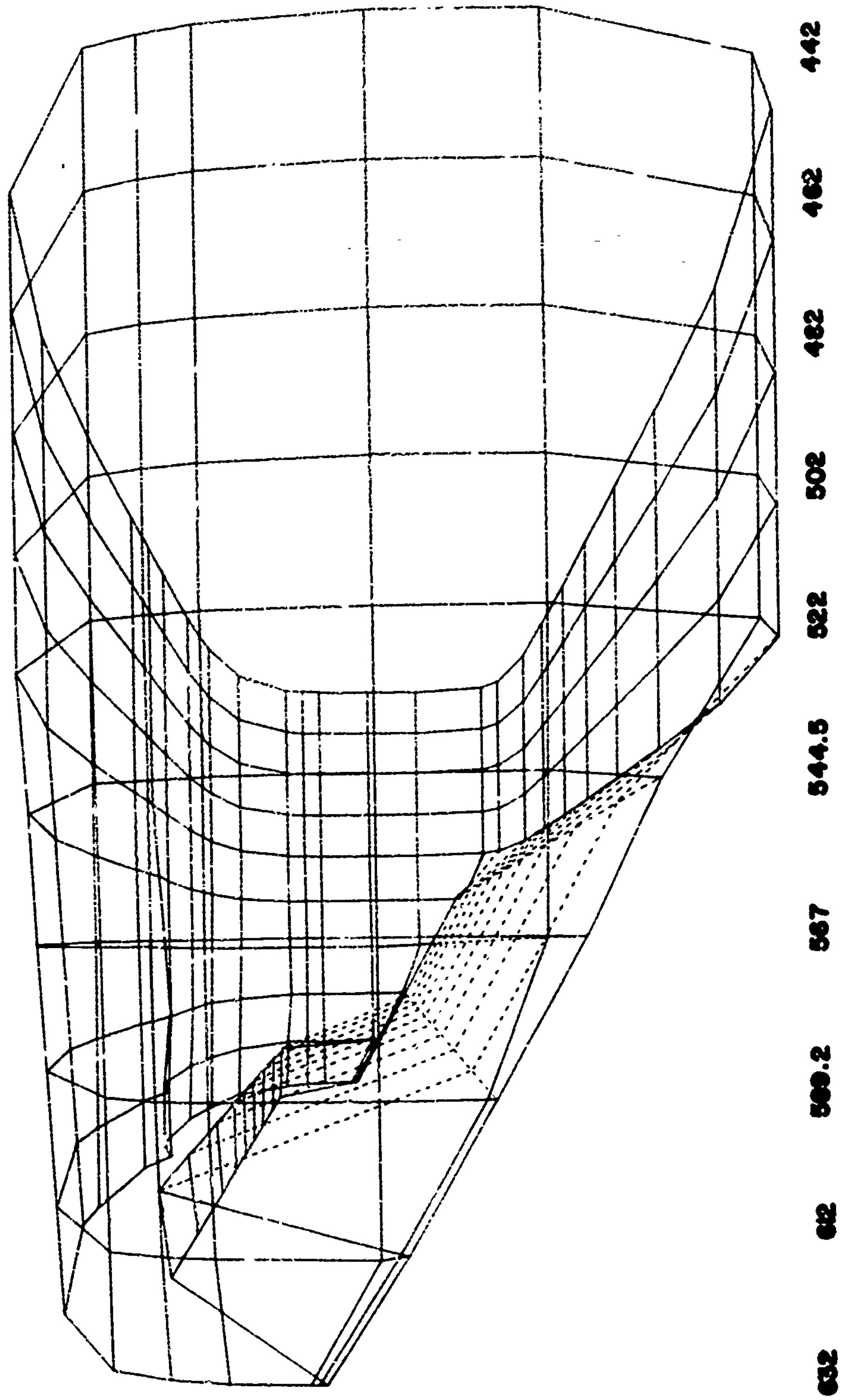


Figure 42 Aft Fuselage Finite Element Model, FS 442-632

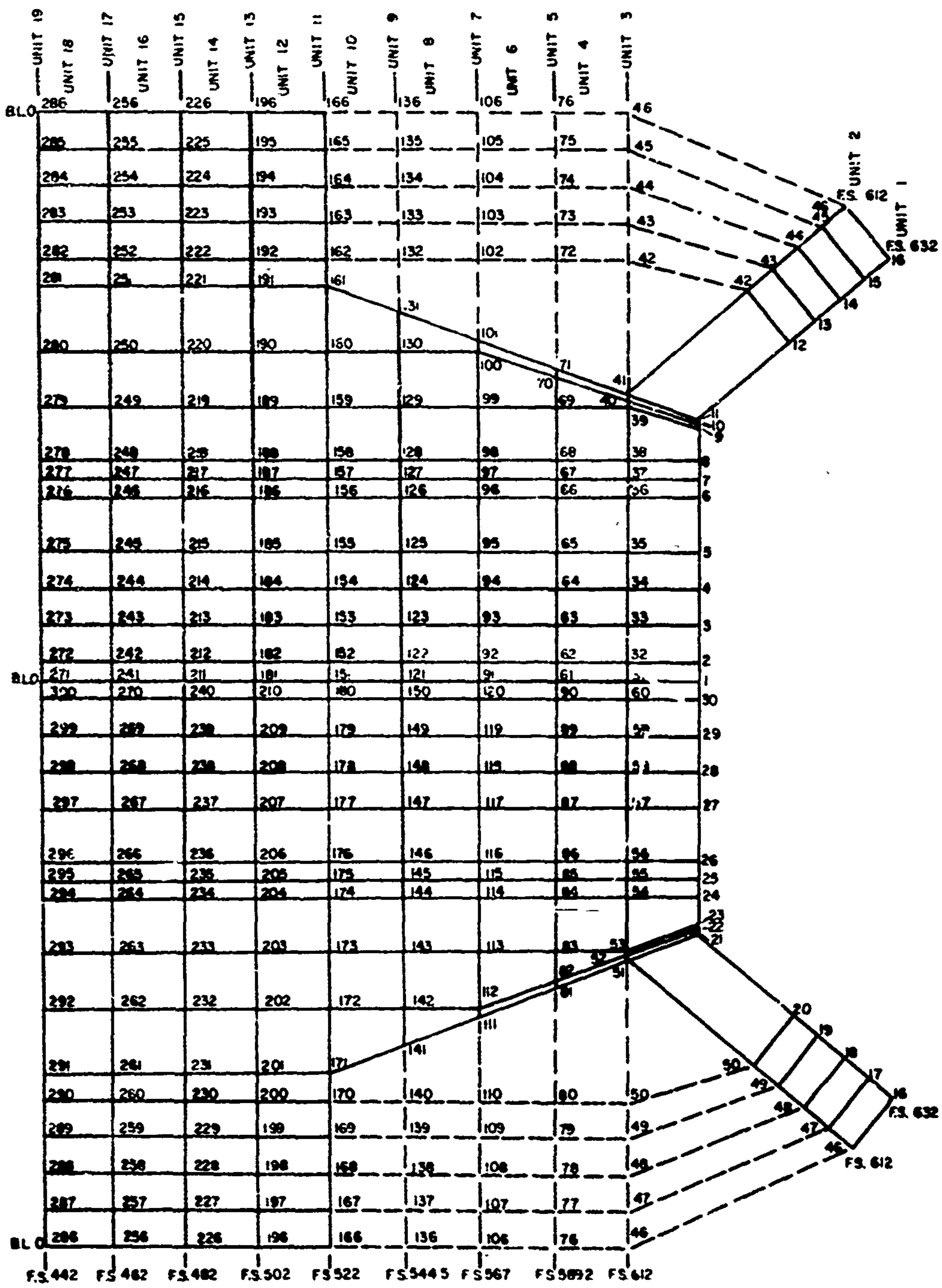
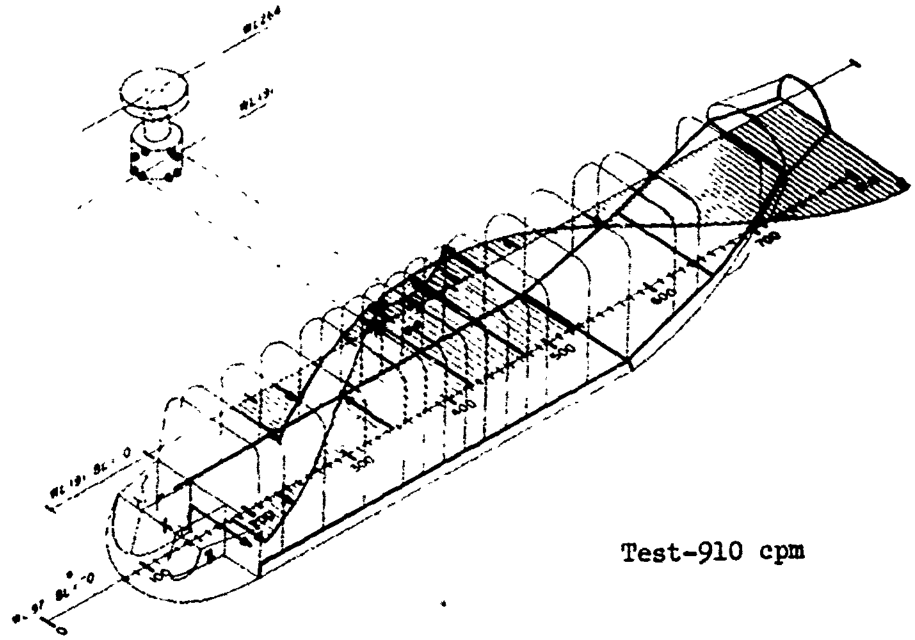
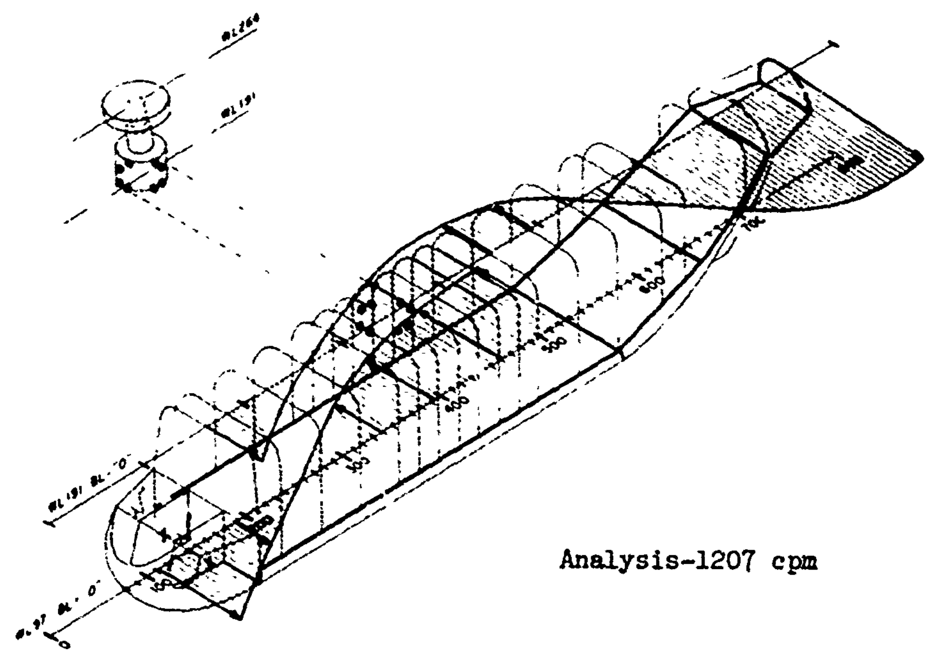


Figure 43 Development of Ramp Area PPFRAN Model

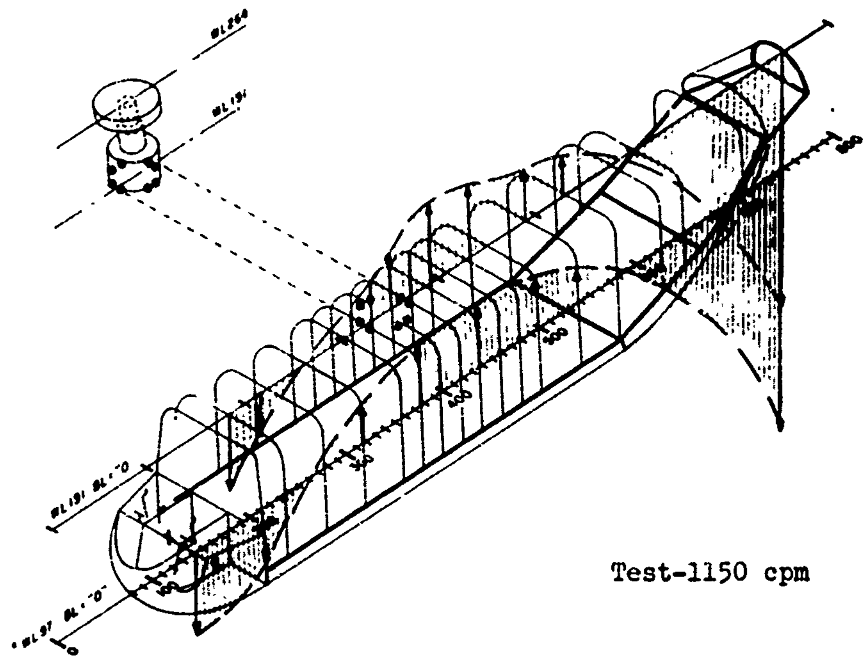


Test-910 cpm



Analysis-1207 cpm

Figure 44 Phase I Correlation of First Lateral Bending Mode - 18 Bay



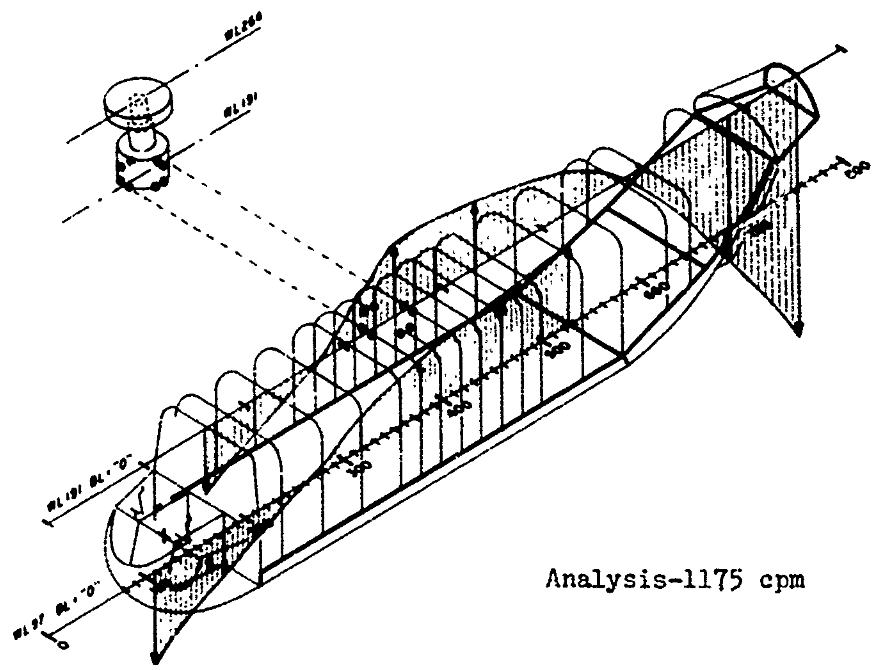
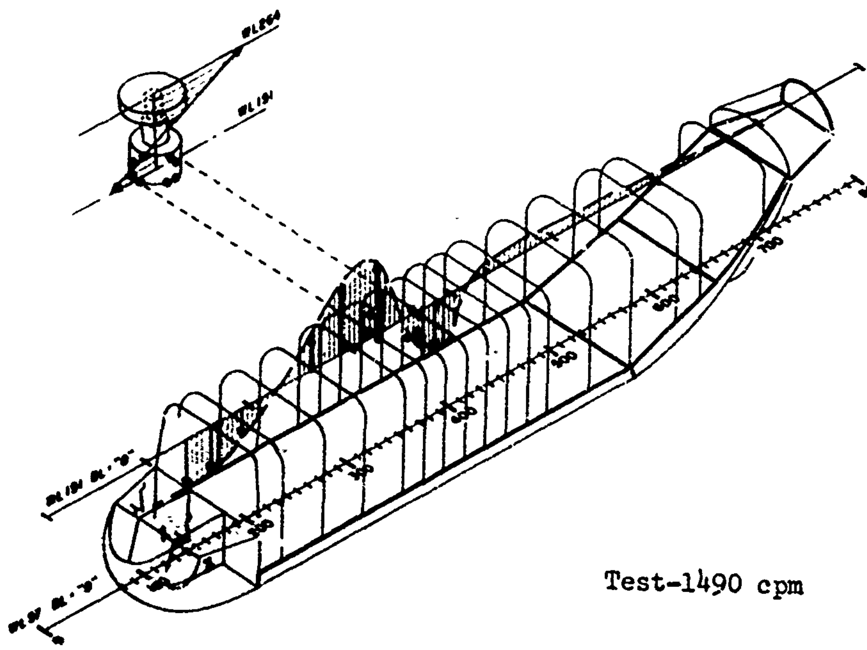
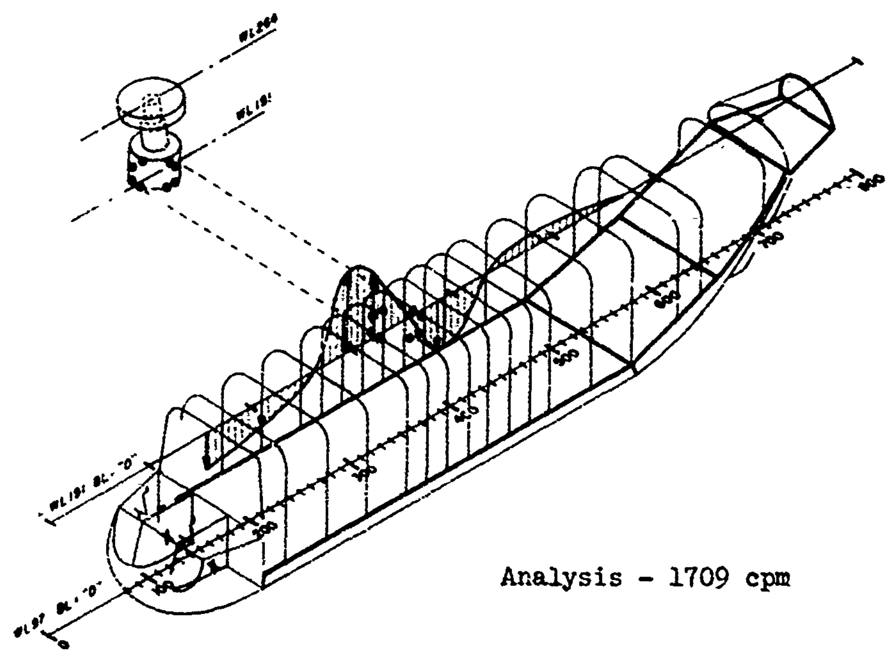


Figure 45 Phase I Correlation of First Vertical Bending Mode - 18 Bay

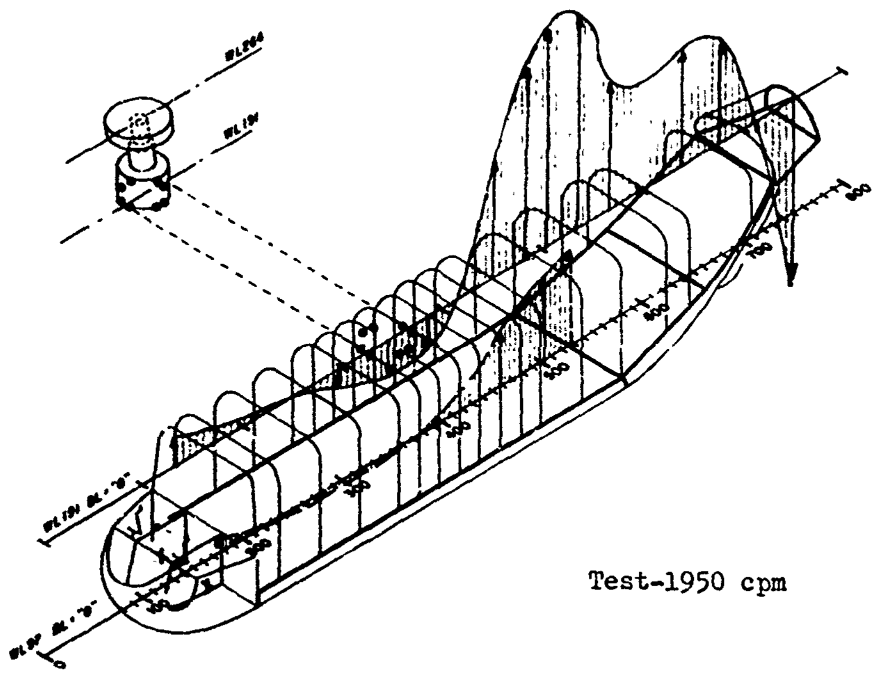


Test-1490 cpm

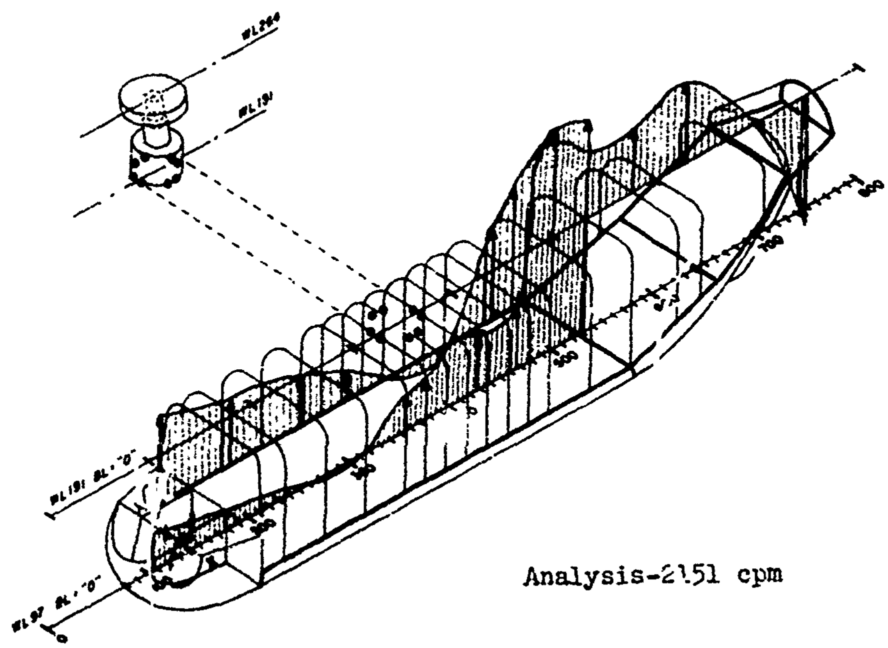


Analysis - 1709 cpm

Figure 46 Phase I Correlation of Transmission Pitch Mode - 18 Bay



Test-1950 cpm



Analysis-2151 cpm

Figure 47 Phase I Correlation of Second Vertical Bending Mode - 18 Bay

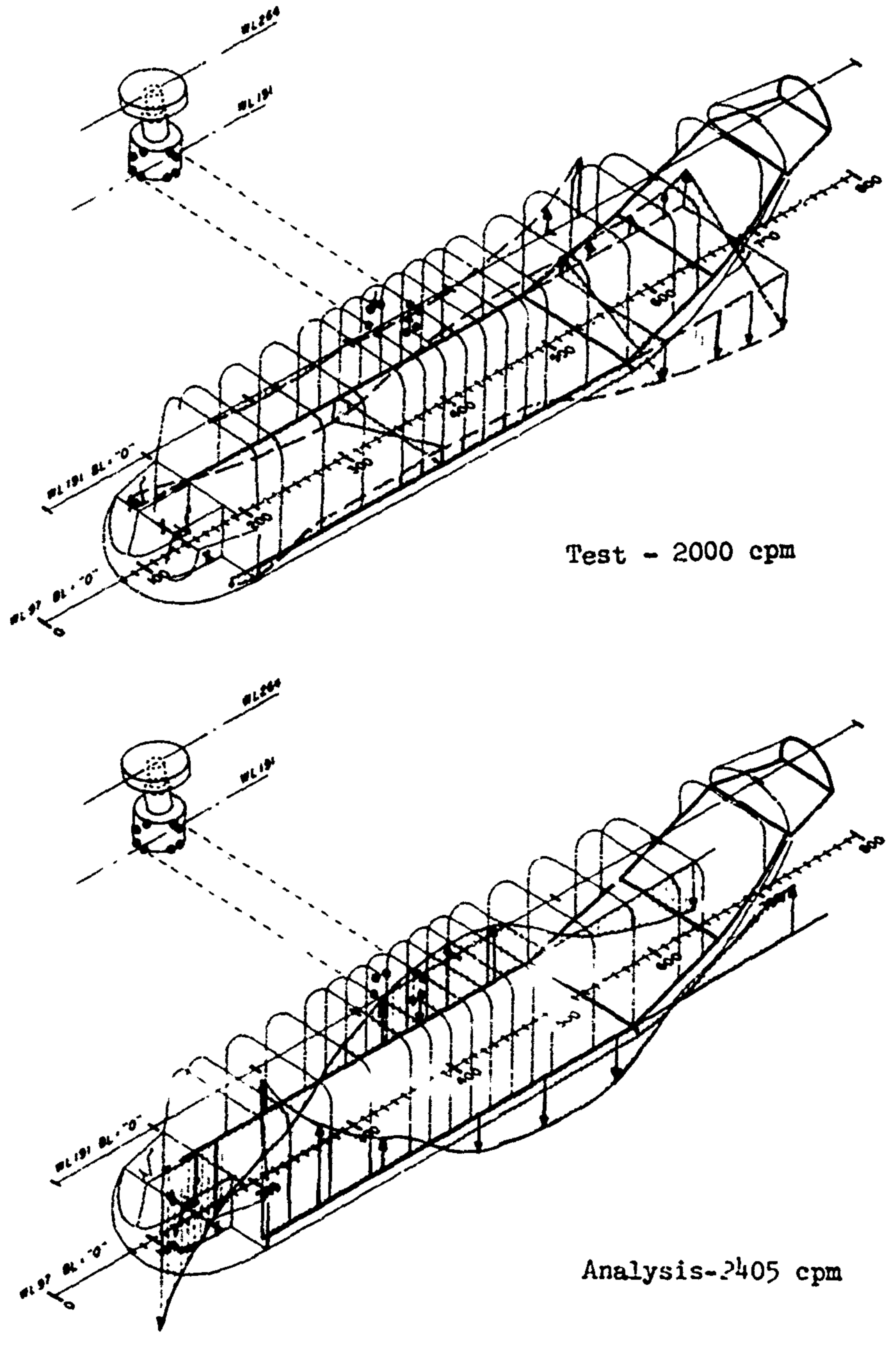


Figure 48 Phase I Correlation of Transmission Roll Mode - 18 Bay

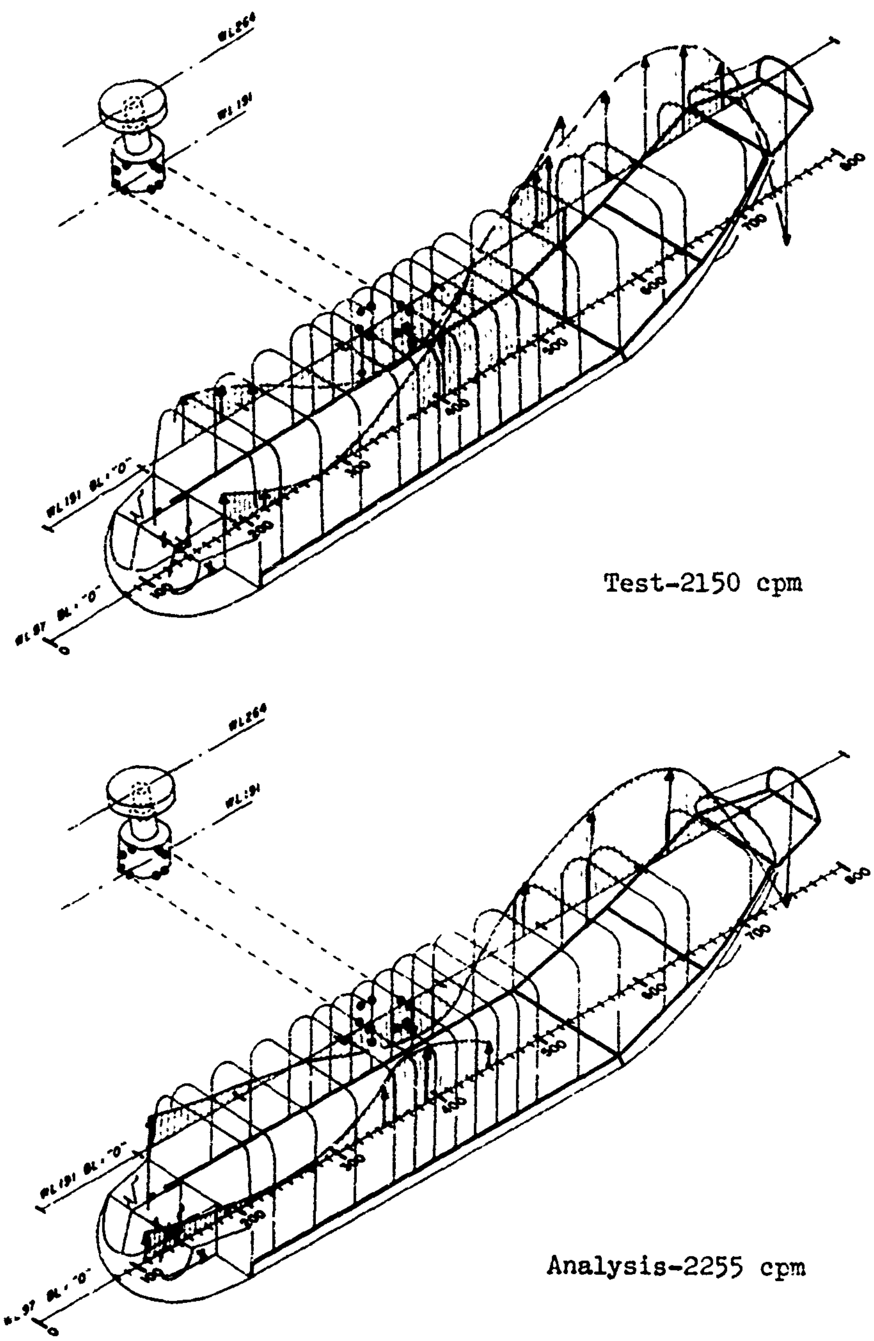


Figure 49 Phase I Correlation of Transmission Vertical Mode - 18 Bay

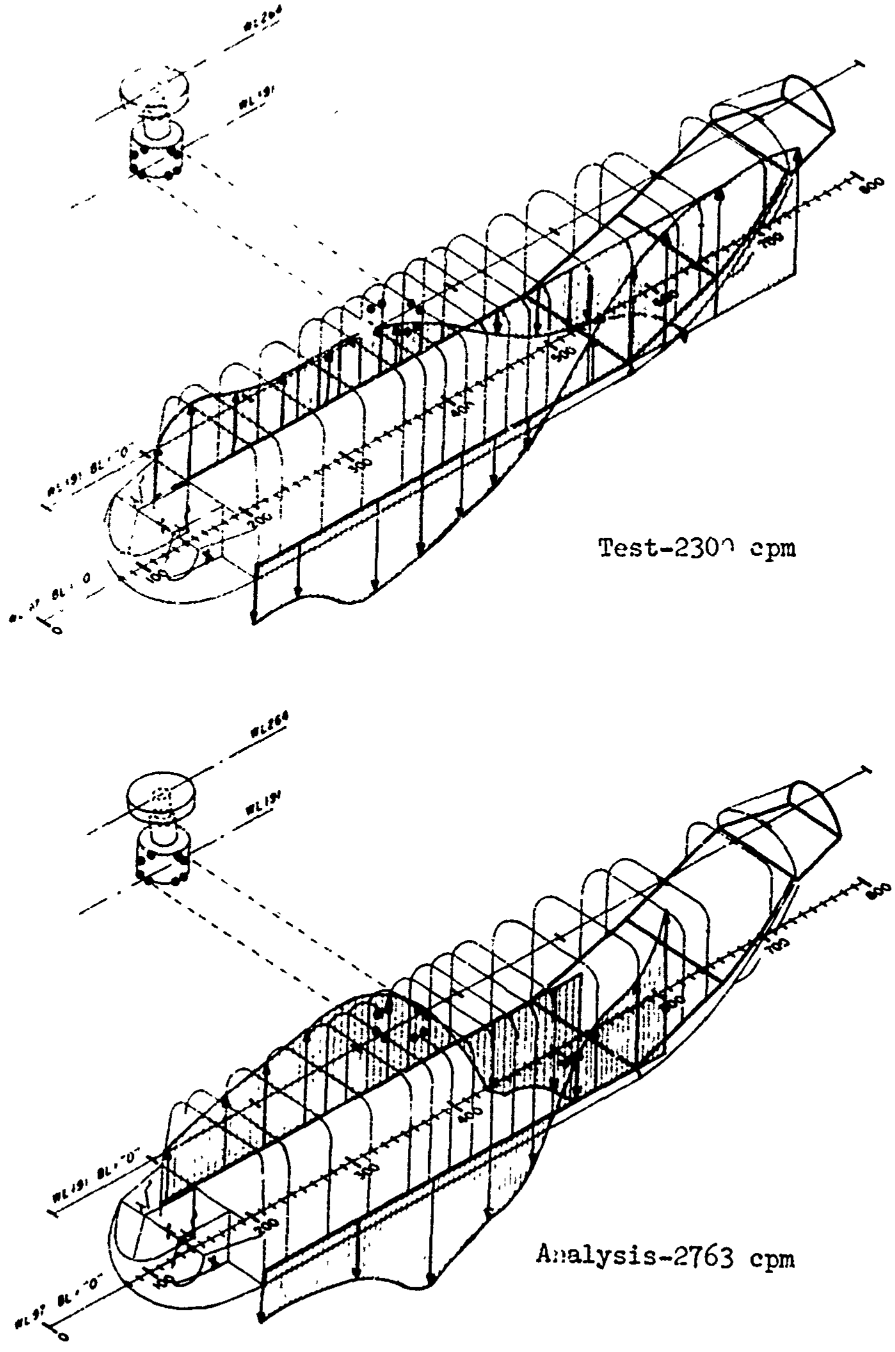
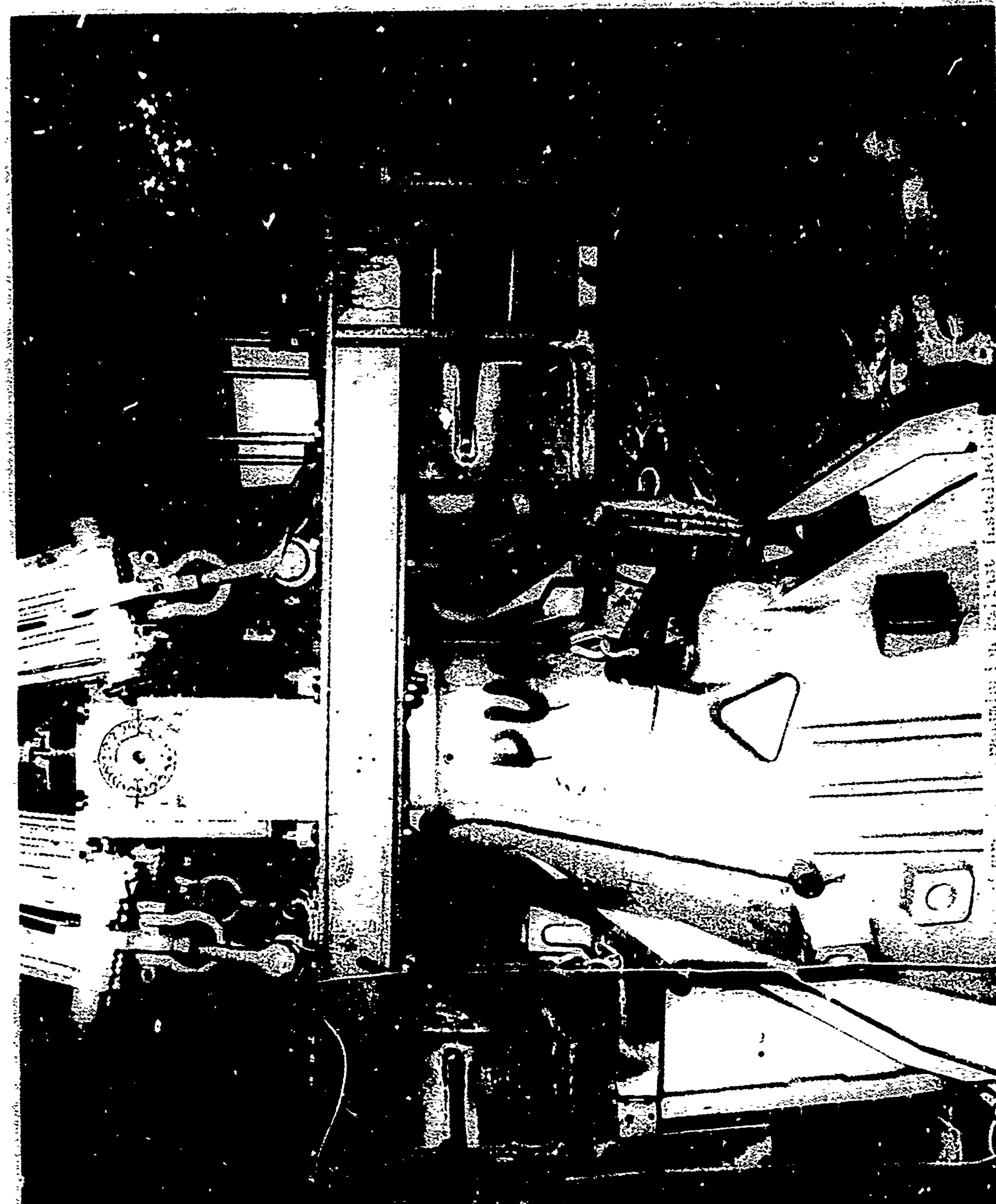


Figure 50 Phase I Correlation of Torsion Mode - 18 Bay



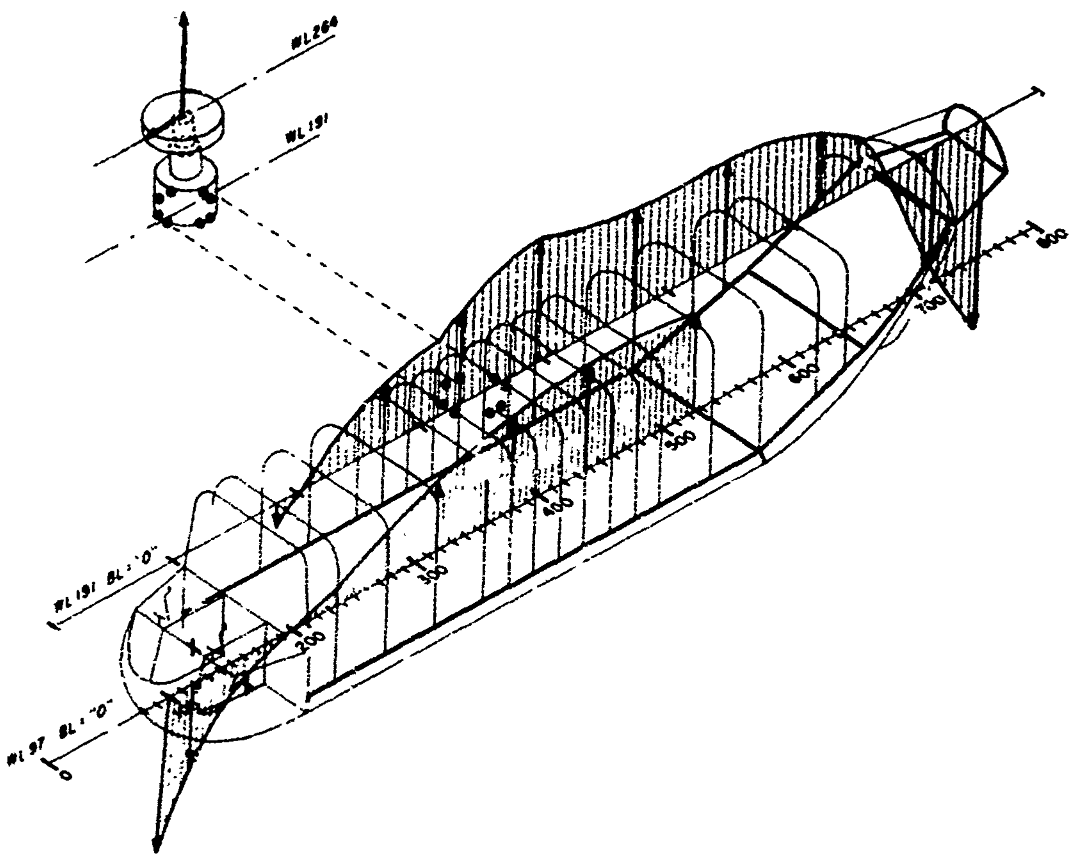


Figure 54 Phase II test - First Vertical Bending Mode 440 cpm

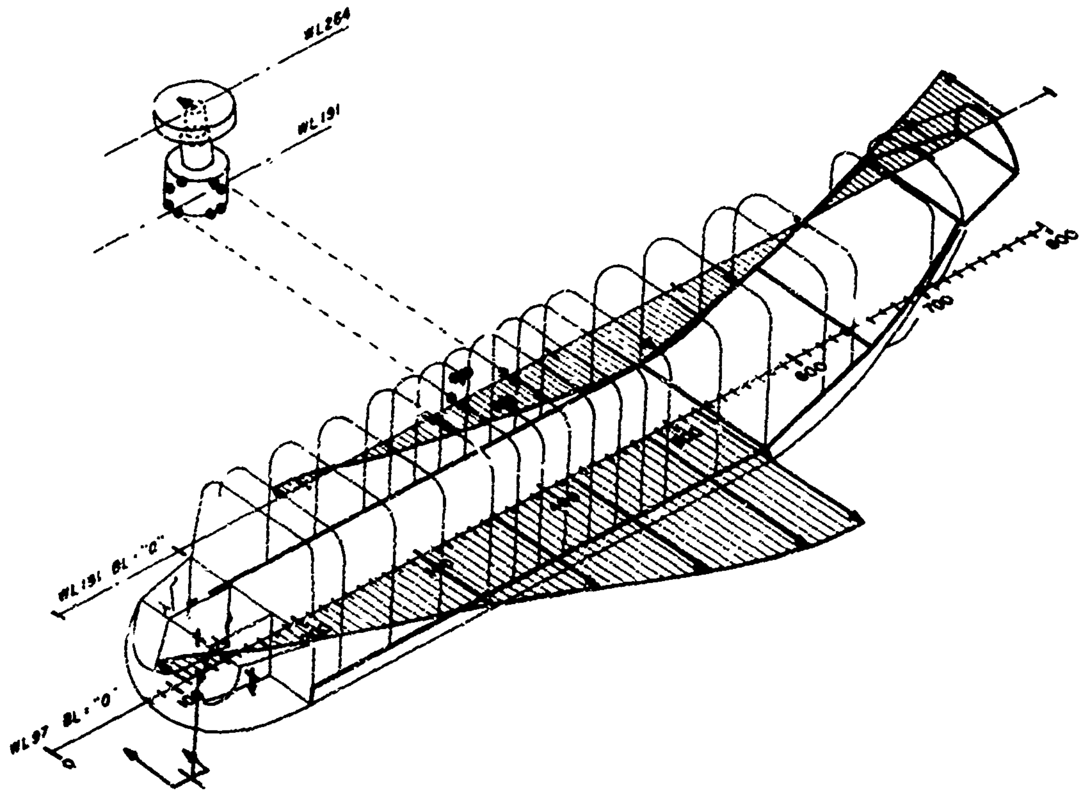


Figure 55 Phase II Test - First Lateral Bending Mode - 615 cpm

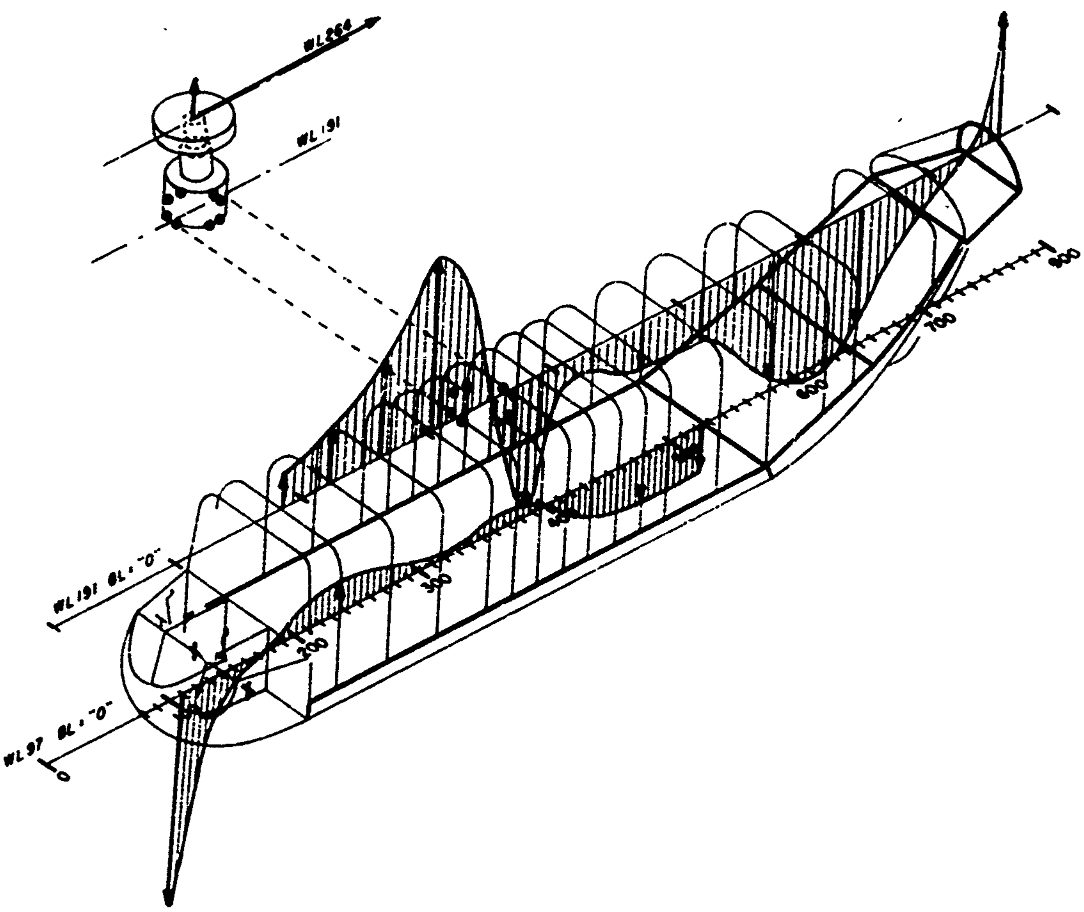


Figure 56 Phase II test - Transmission Pitch Model - 740 cpm

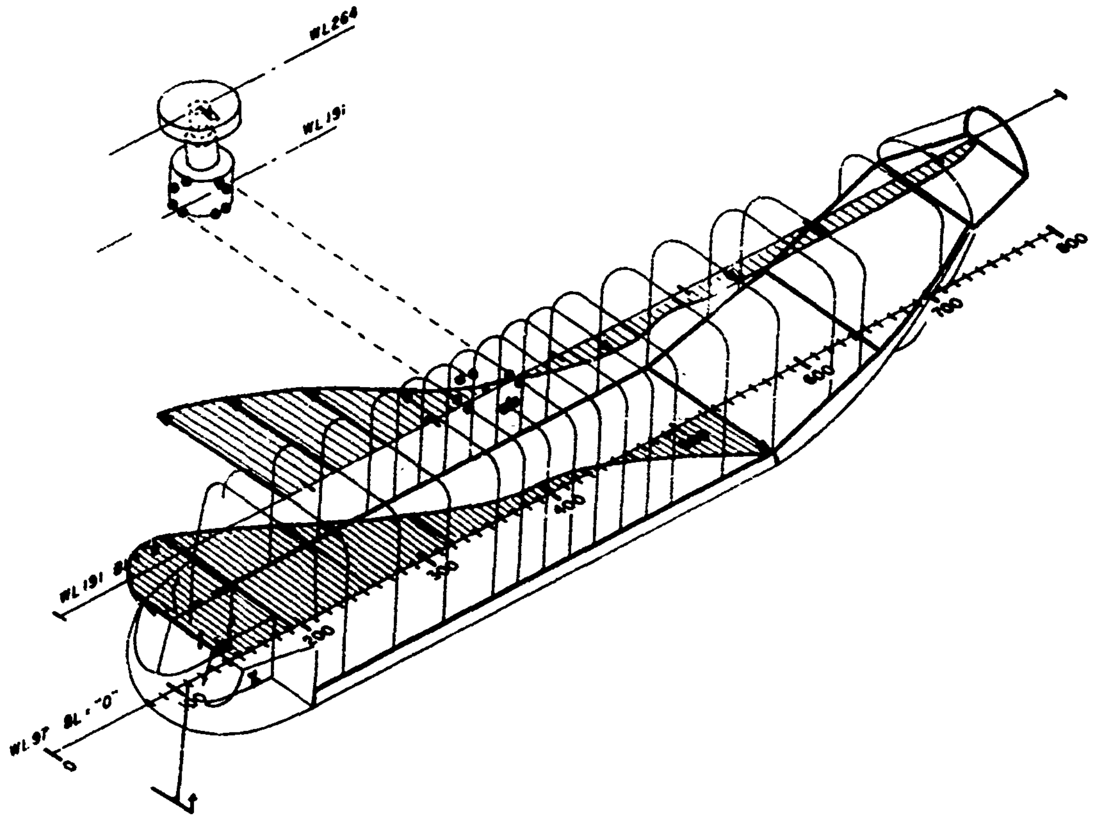


Figure 57 Phase II test - Forward Cabin Lateral Model - 840 cpm

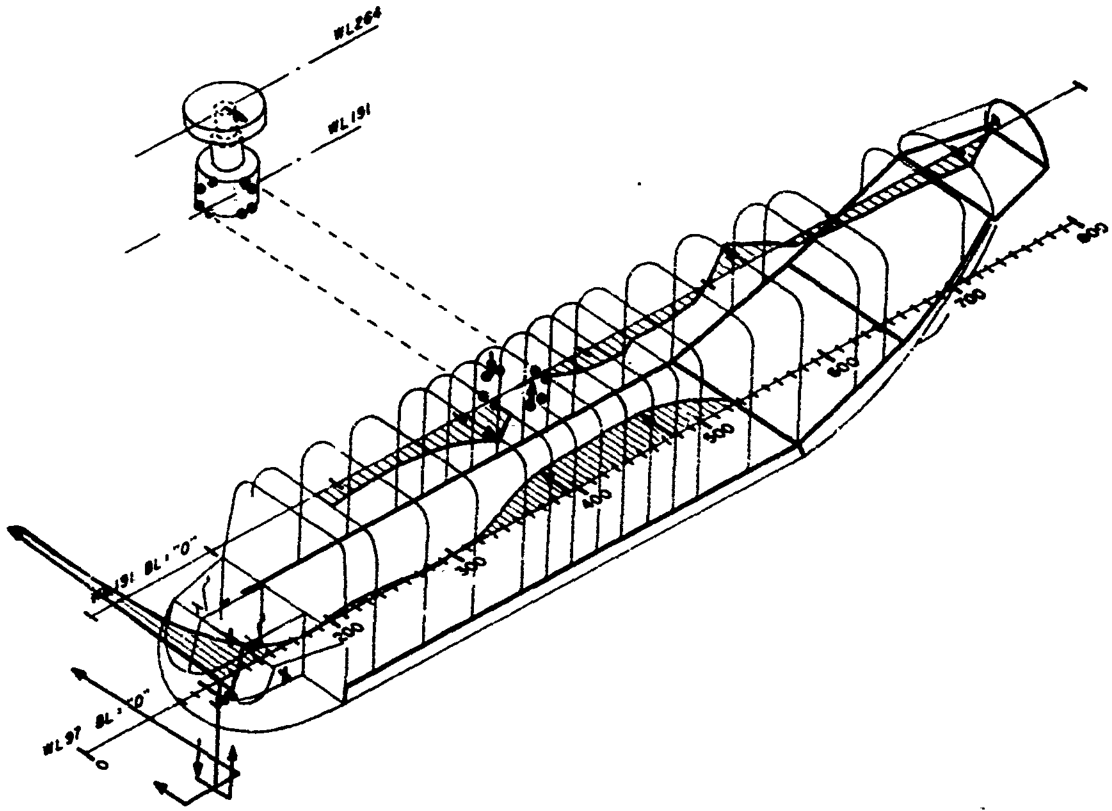


Figure 58 Phase II test - Nose Block Lateral/Roll Mode - 930 cpm

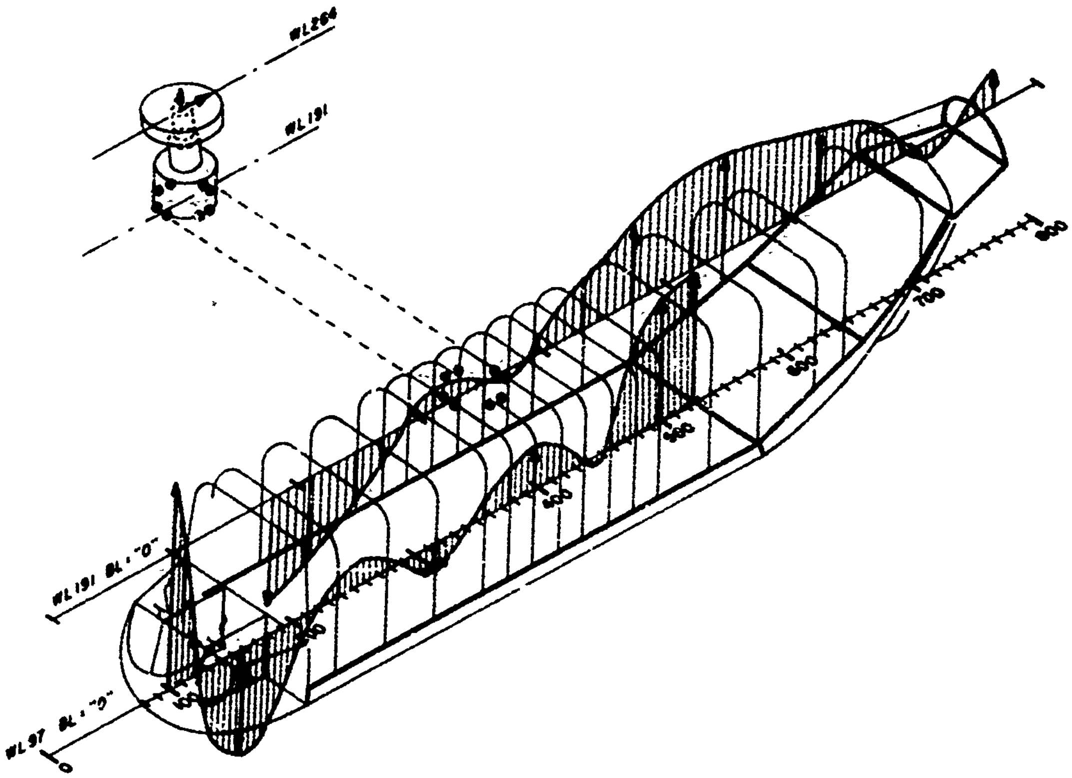


Figure 59 Phase II test - Nose Block Vertical, Transmission Pitch Model - 970 cpm

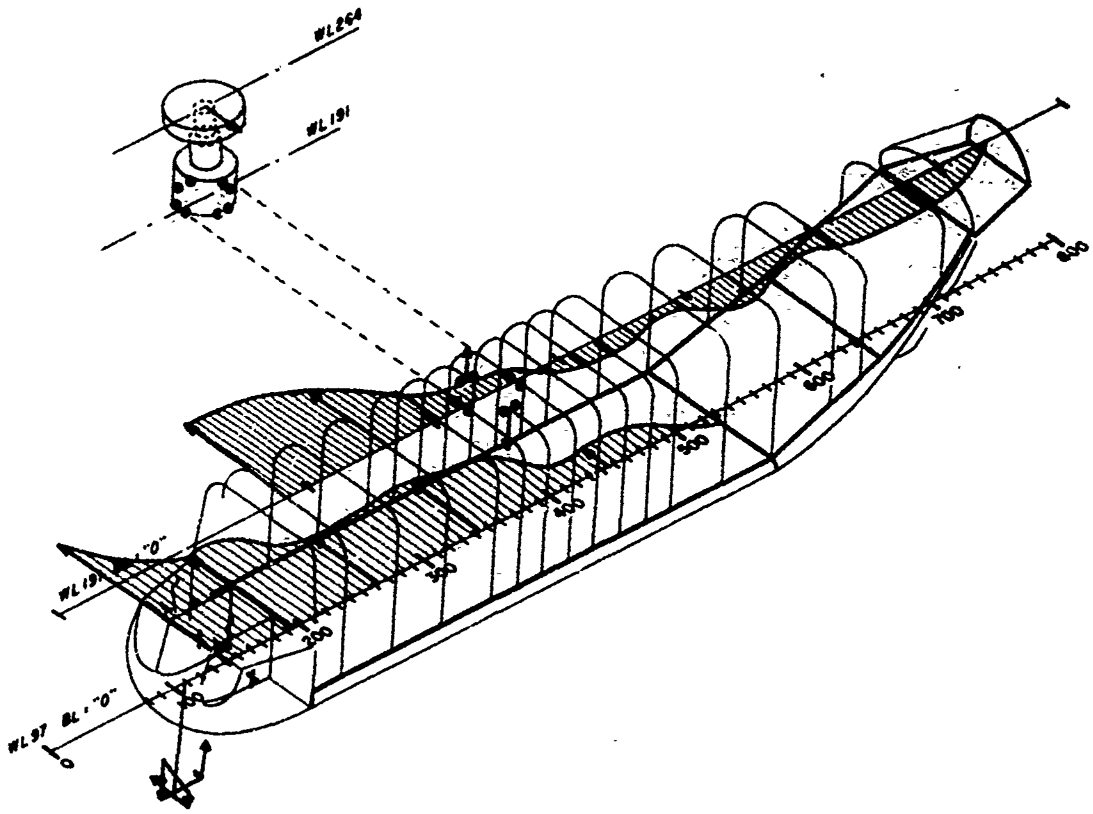


Figure 60 Phase II test - Forward Cabin/Nose Block Lateral Model - 990 cpm

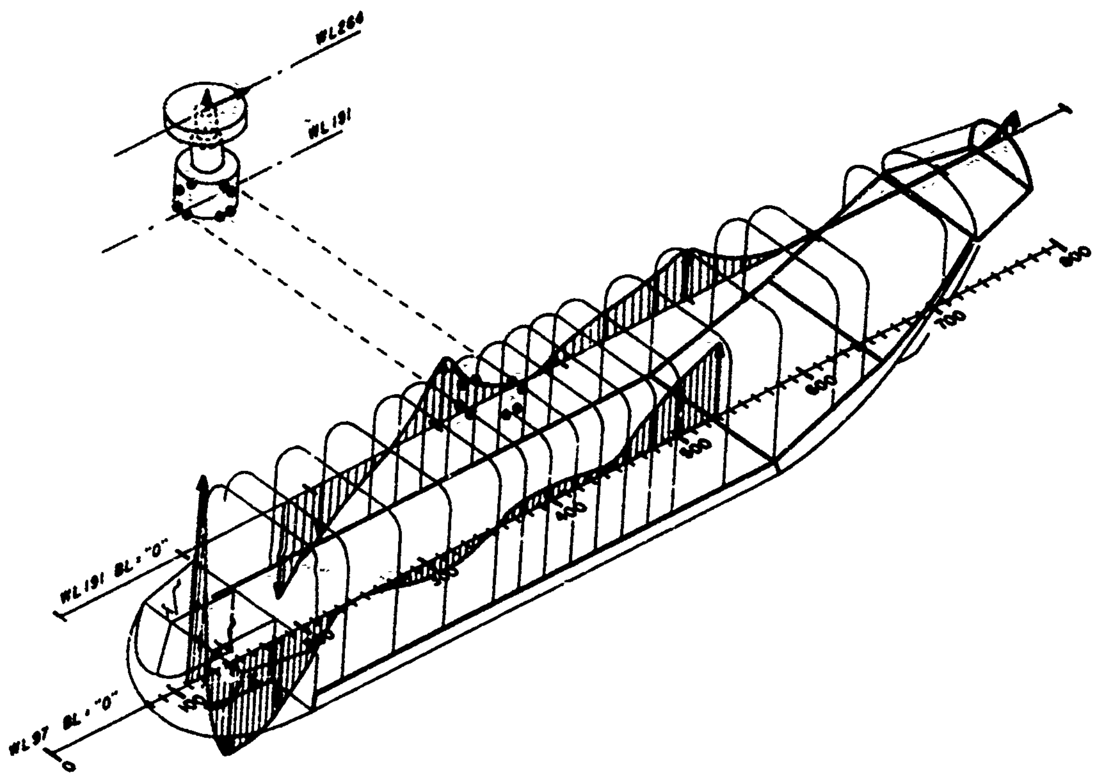


Figure 61 Phase II test - Nose Block Vertical Model - 1050 cpm

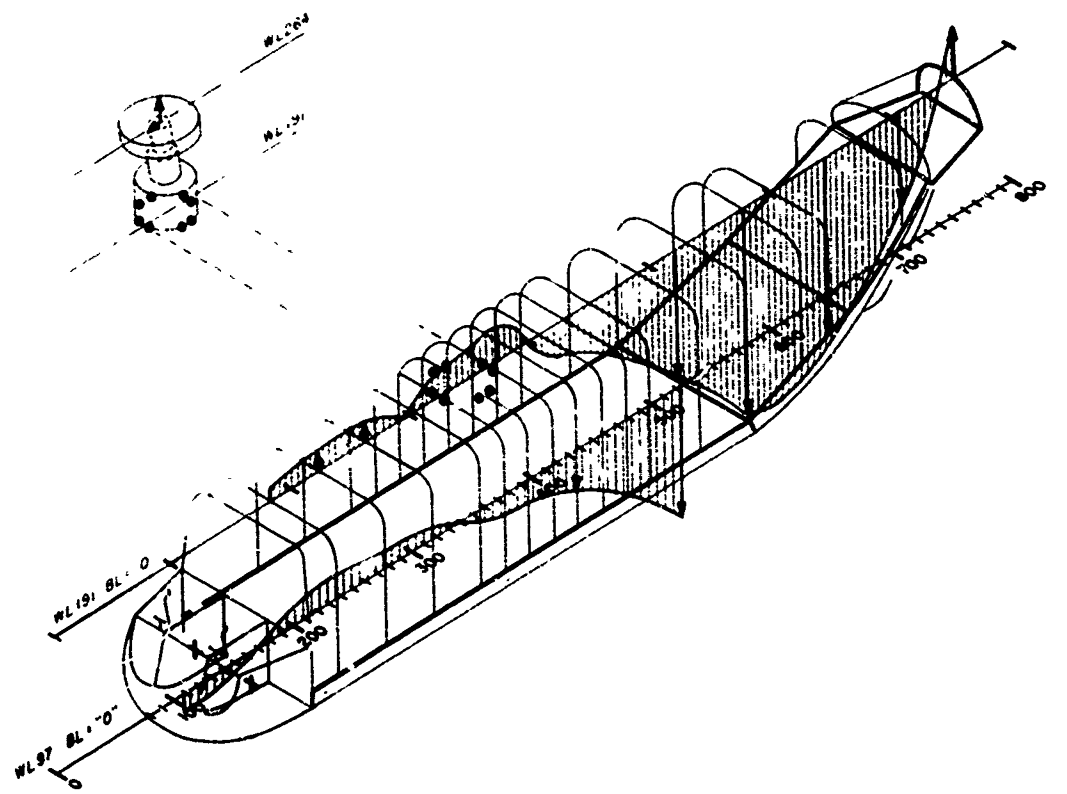


Figure 62 Phase II test - Second Vertical Bending Mode - 1290 cpm

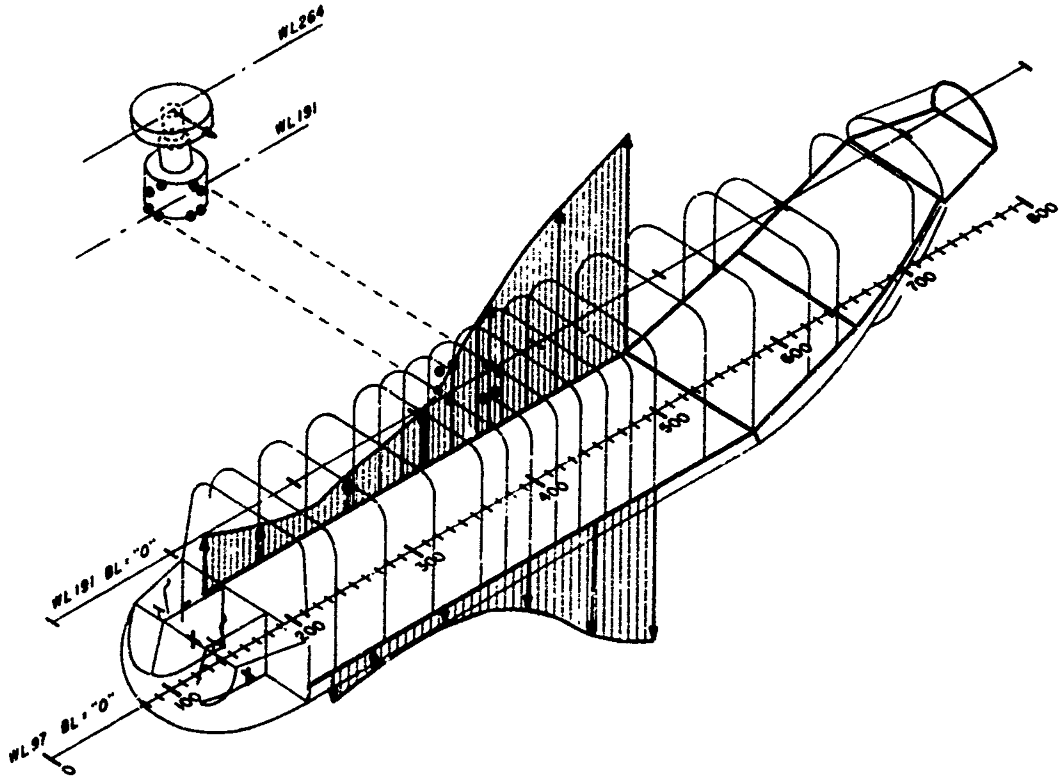


Figure 63a Phase II test - Torsion Mode - 1310 cpm

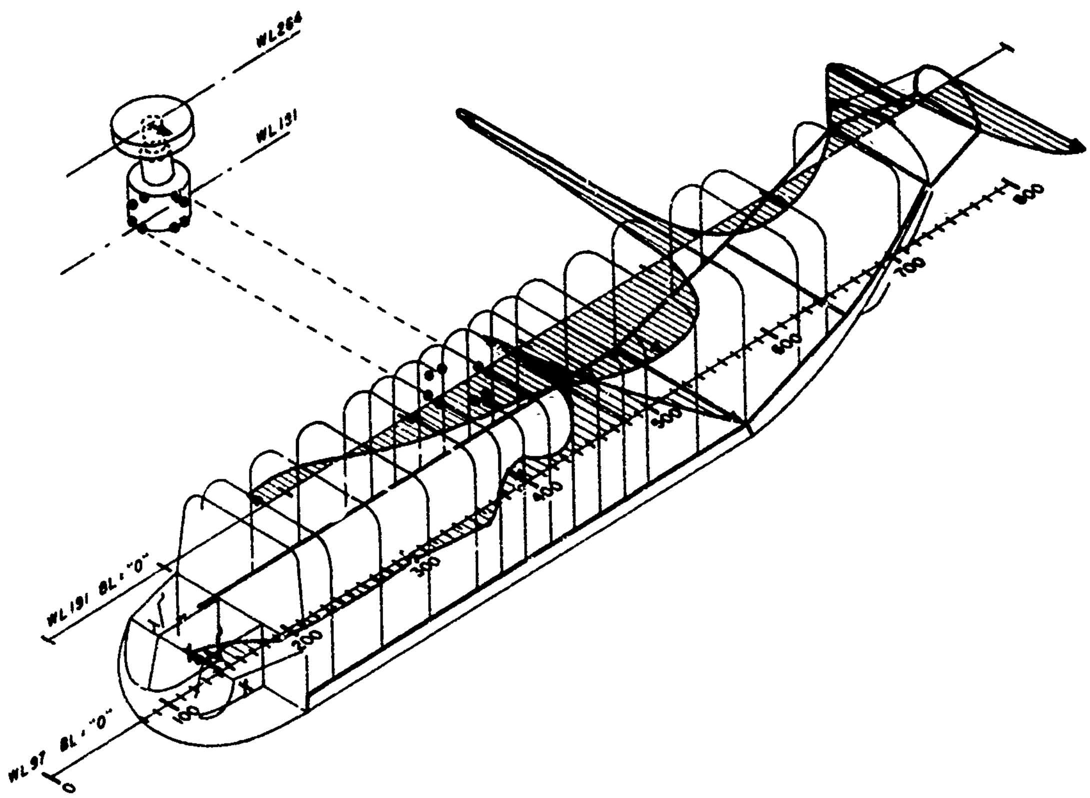


Figure 63b Phase II test - Torsion Mode - 1310 cpm

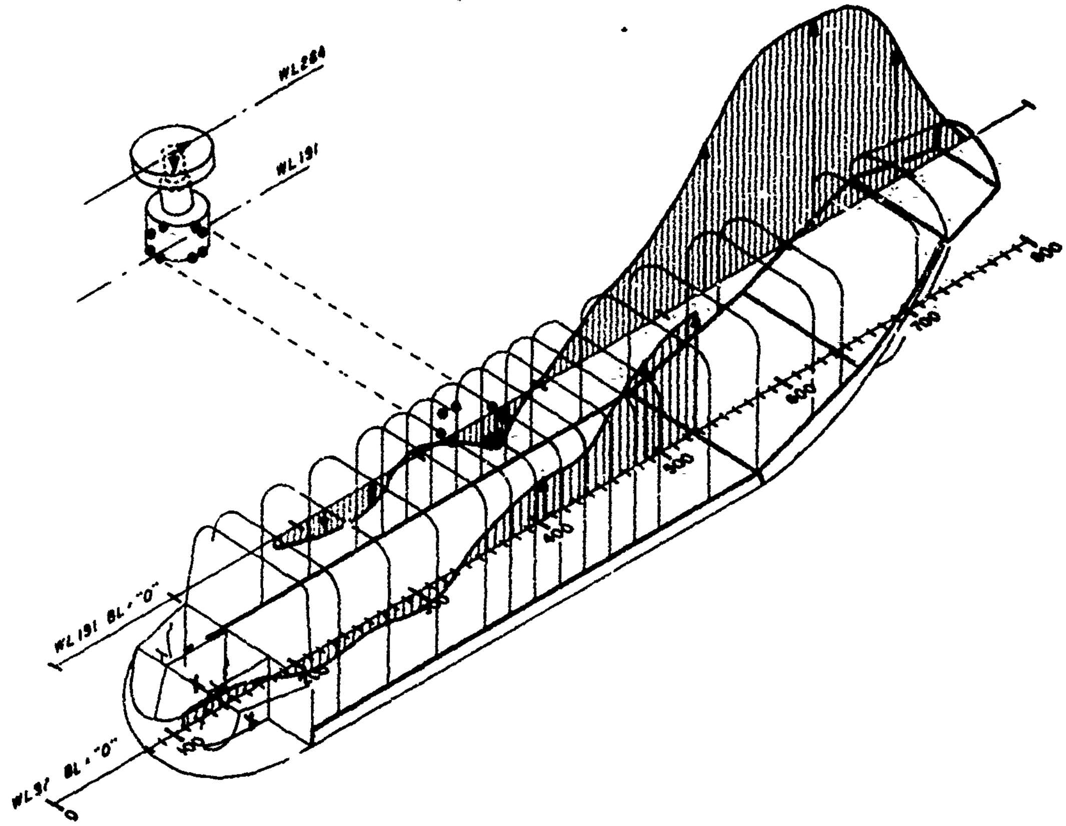


Figure 64 Phase II test - Transmission Vertical/Ramp Vertical Bending Mode - 1425 cpm

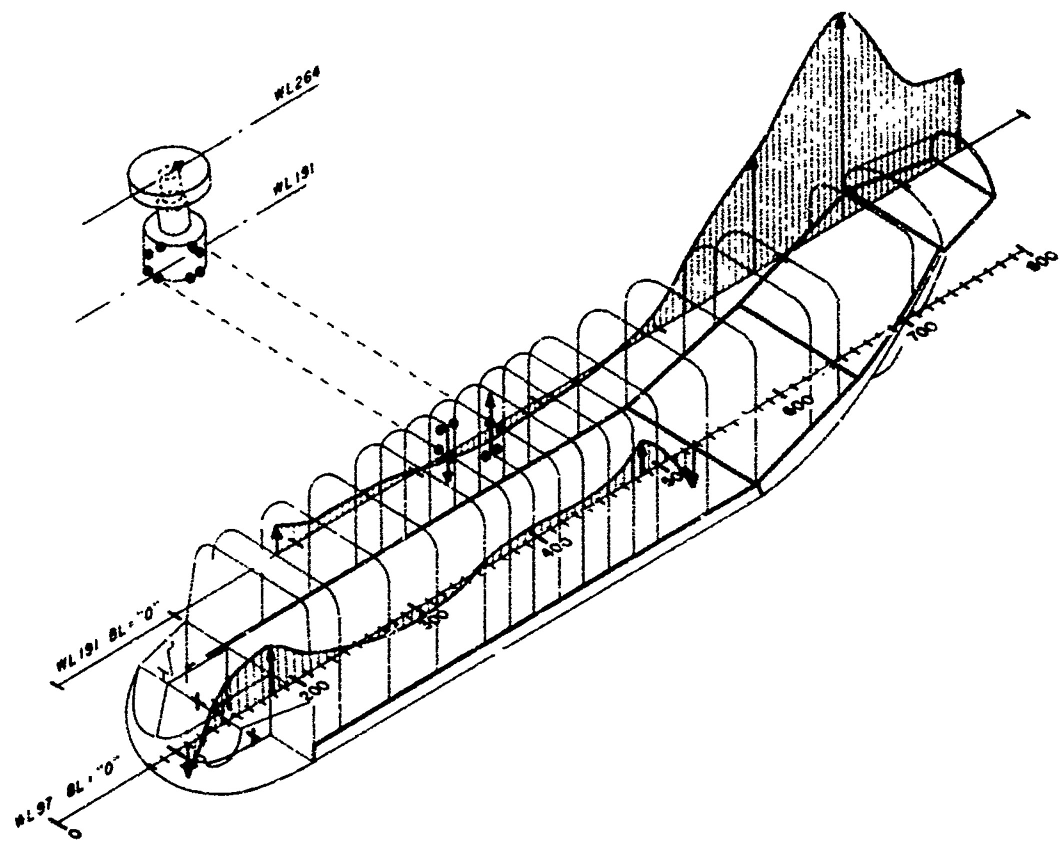


Figure 65 Phase II test - Ramp Vertical Mode - 1640 cpm

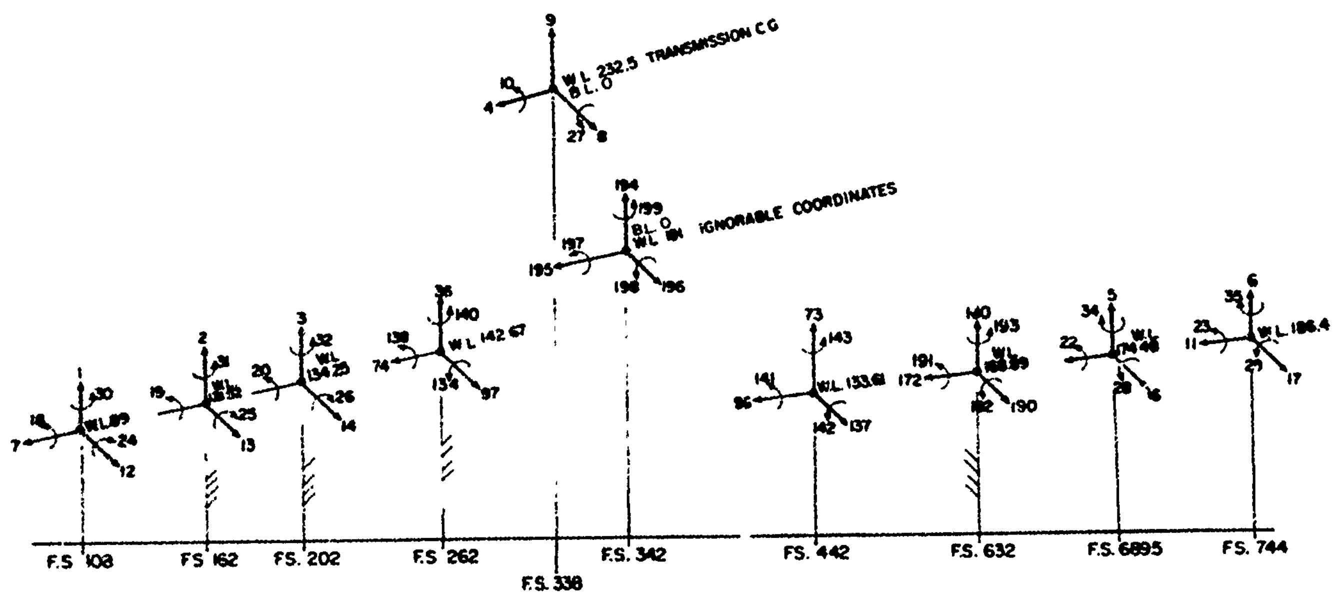


Figure 66 Eighteen Bay Model - Phase II
Beam Degrees of Freedom

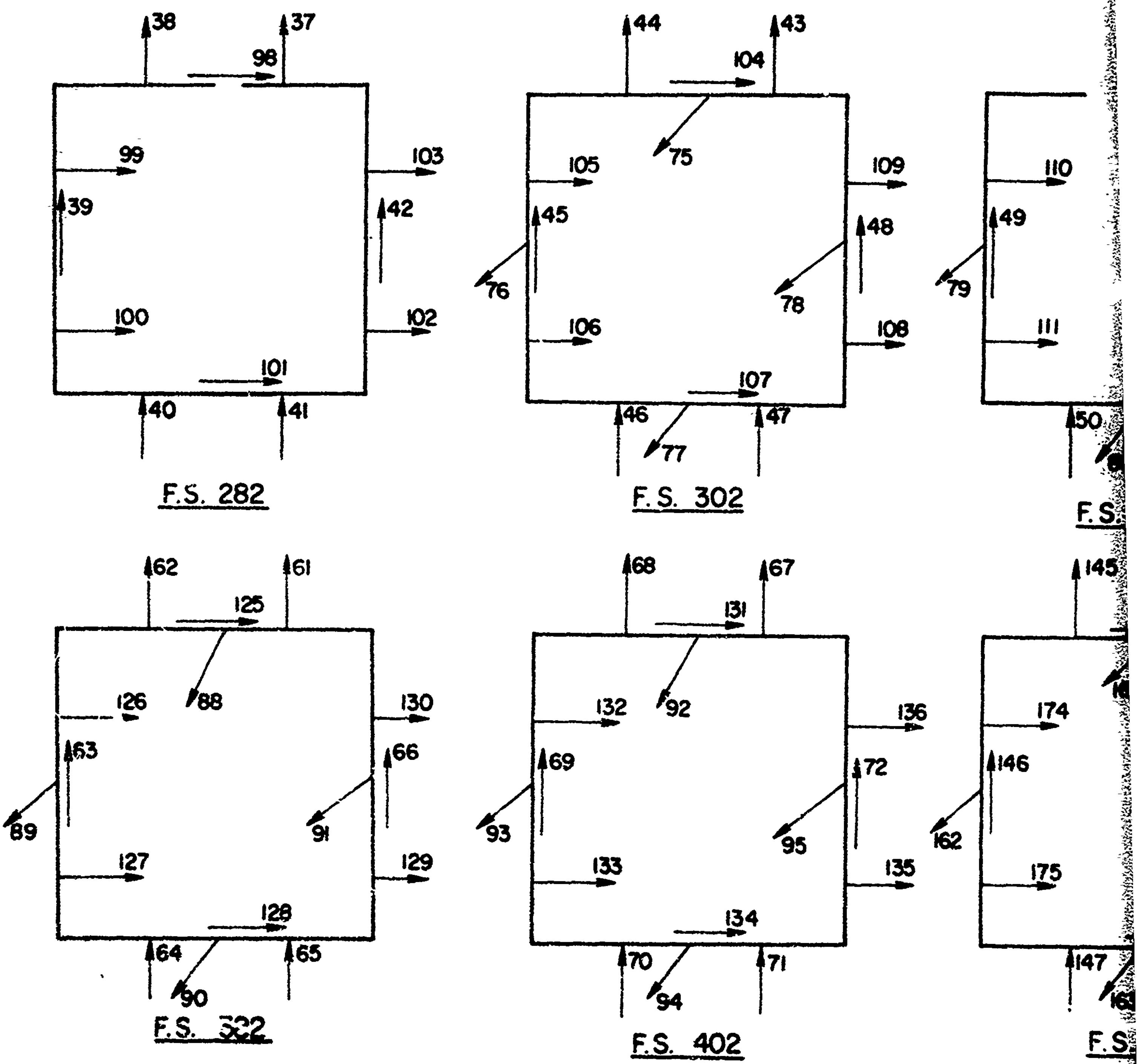
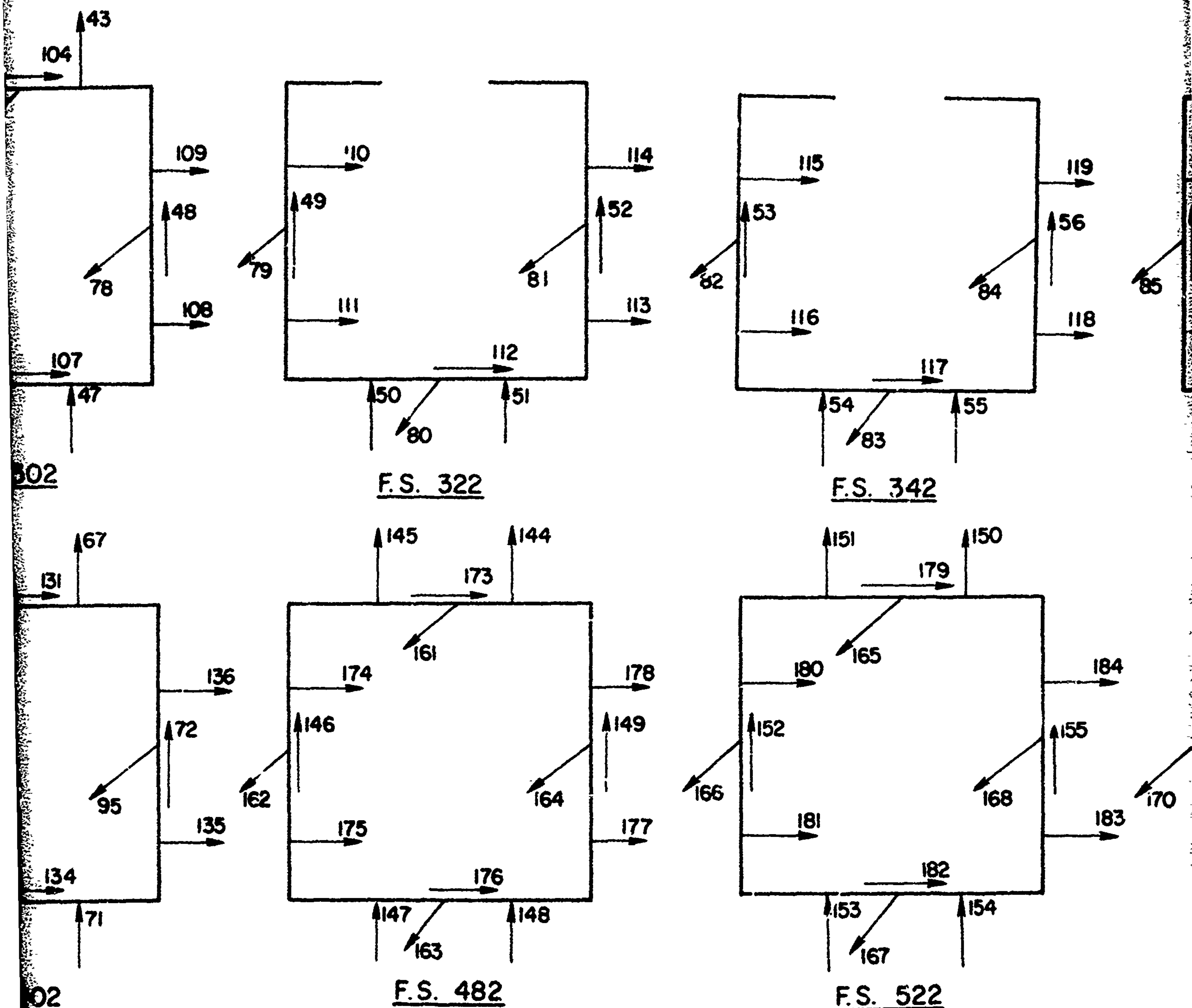


Figure 67 Flexible Frame Degrees of Freedom Allocation (Looking Aft) Final Model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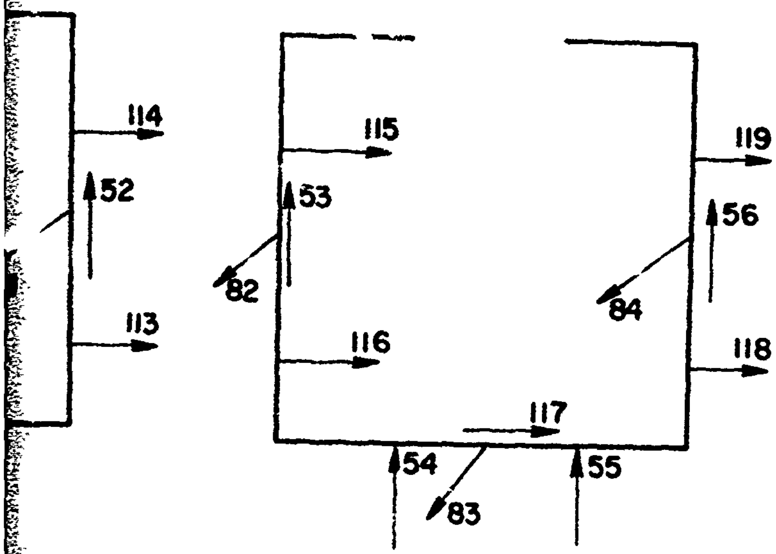
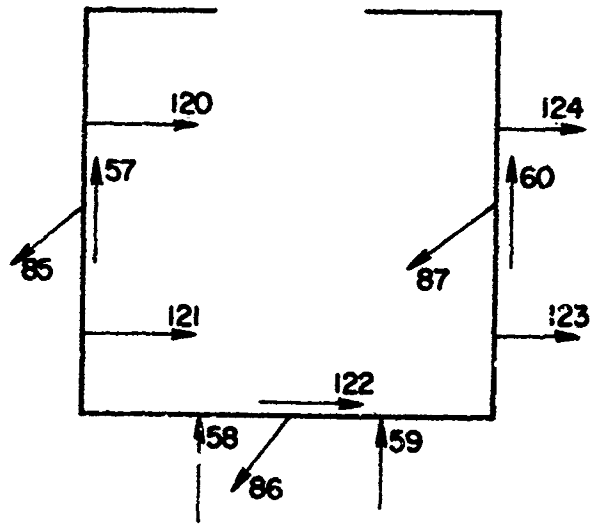


F.S. 342



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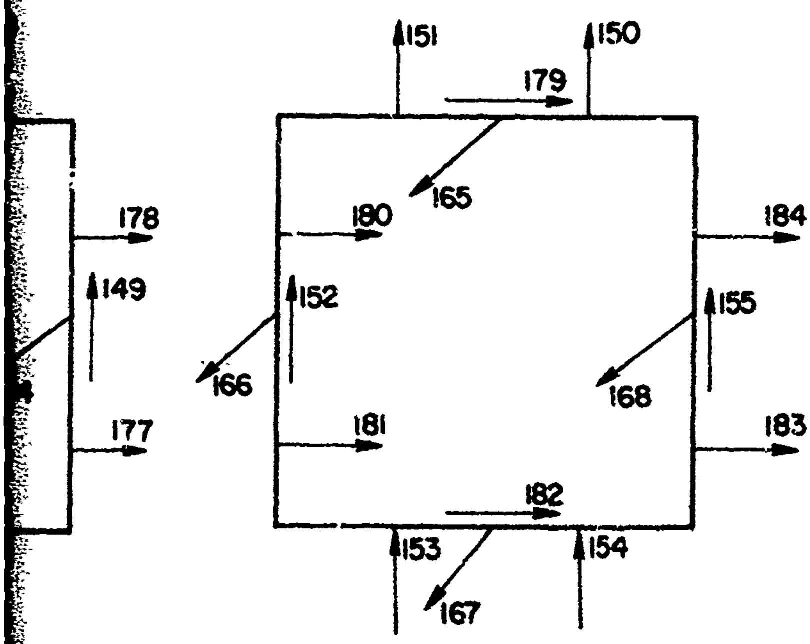

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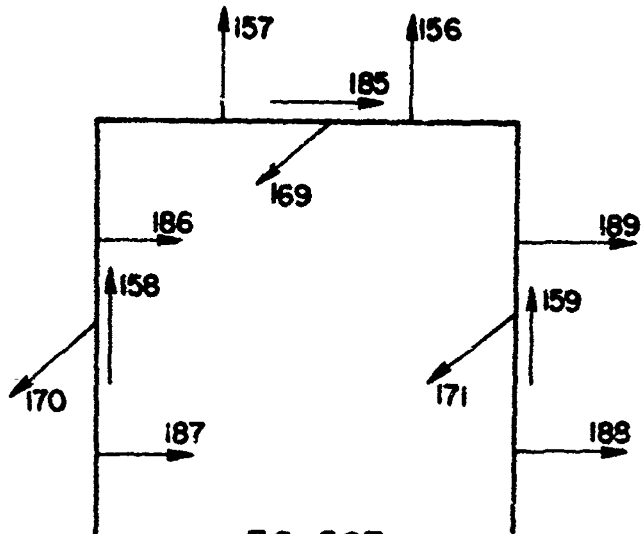

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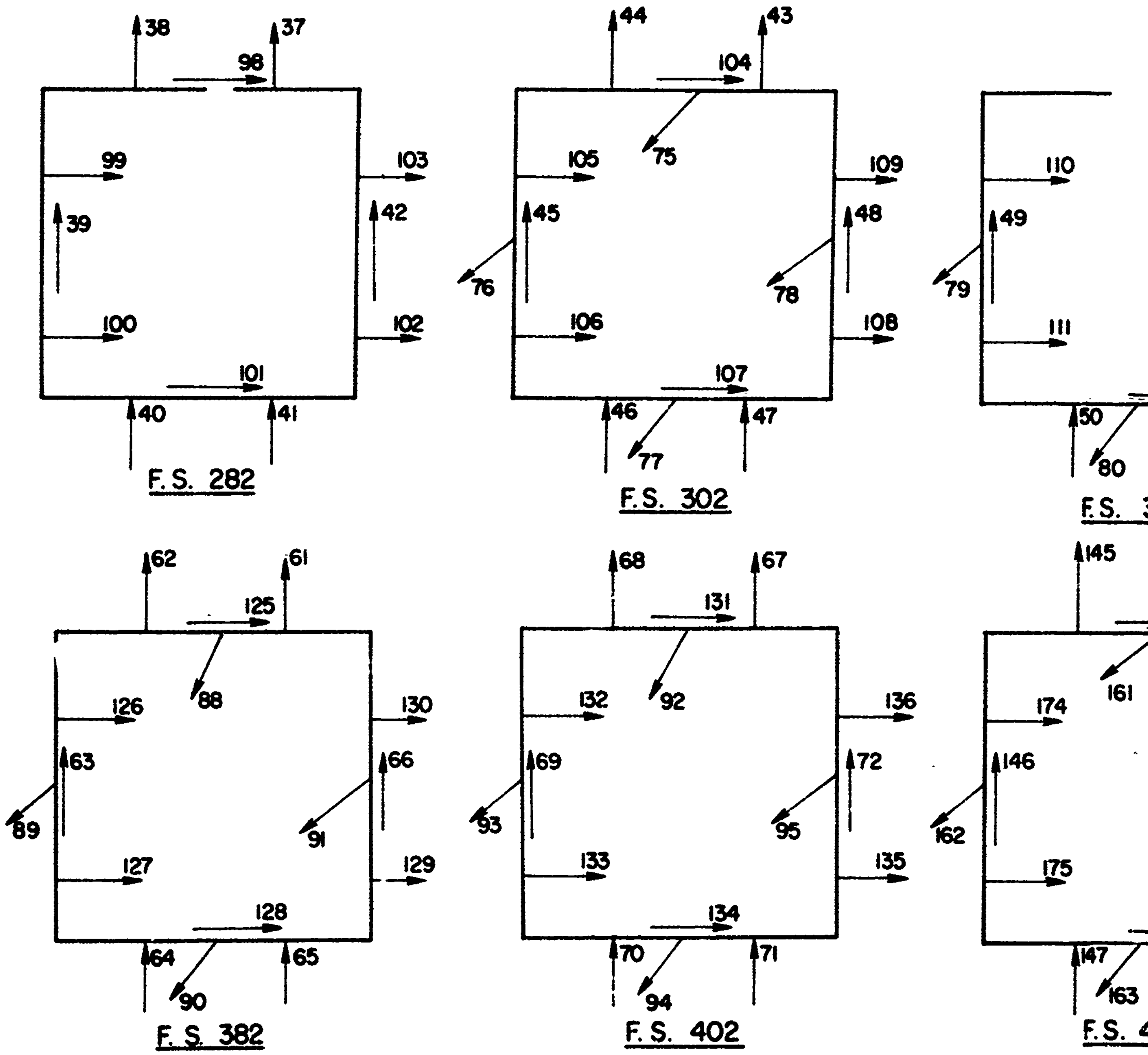
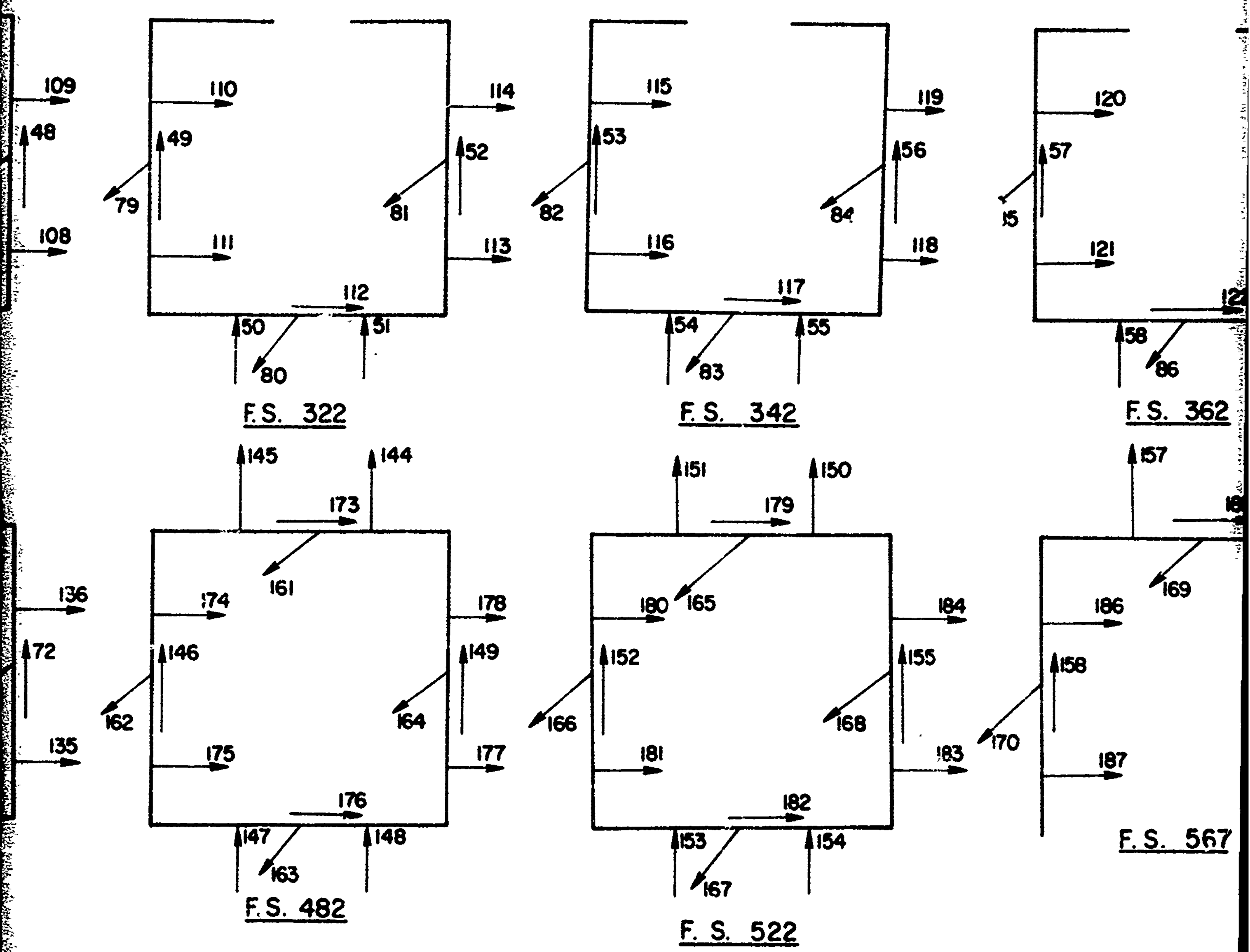


Figure 71 Flexible Frame Degrees of Freedom Allocation (Looking Aft) Final Model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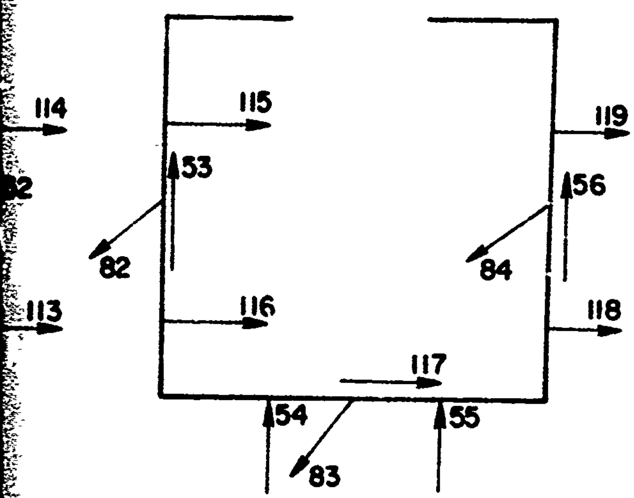
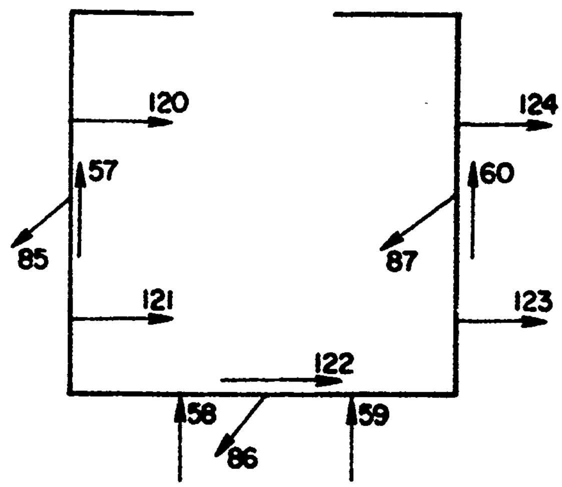


F.S. 342



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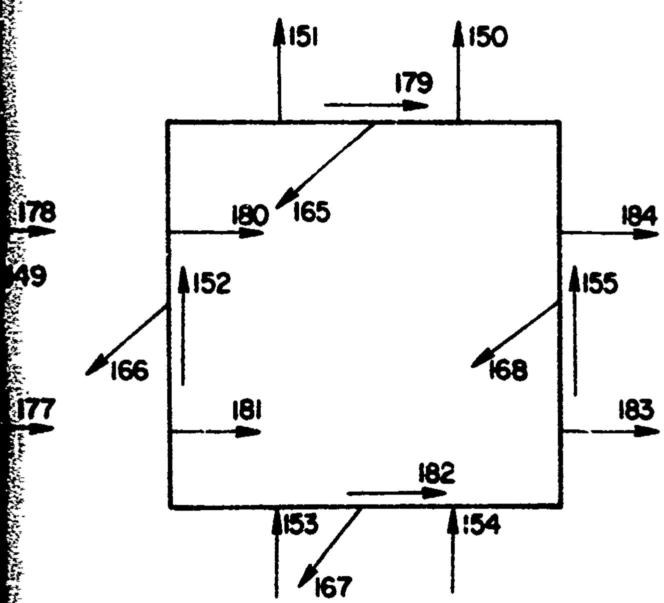
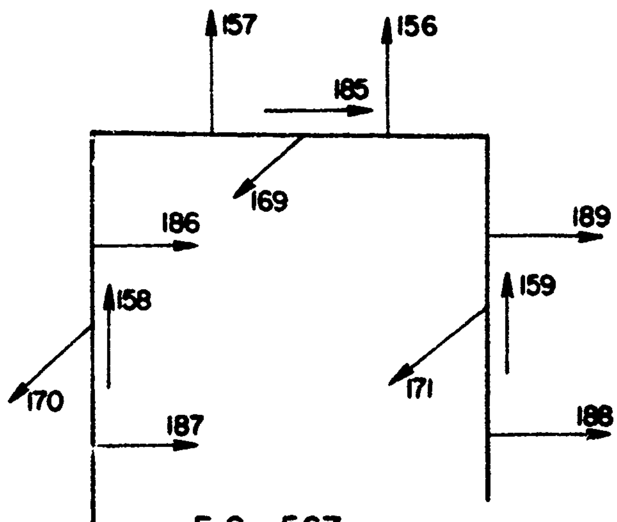


F.S. 522



F.S. 567

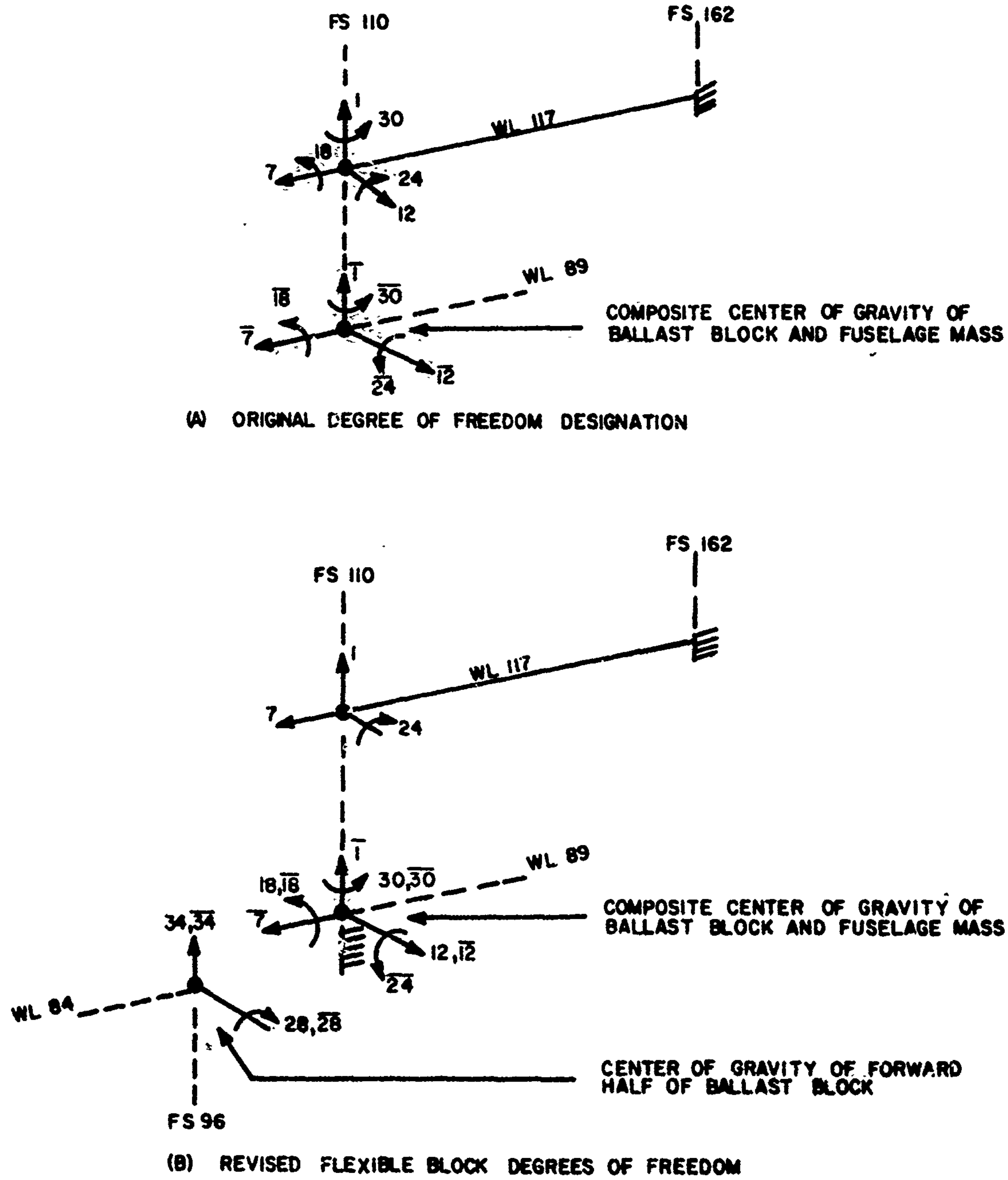
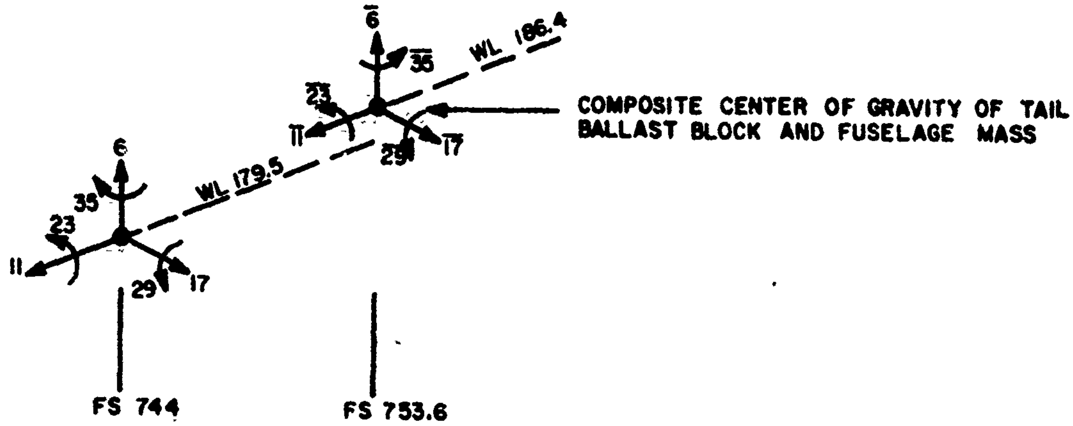
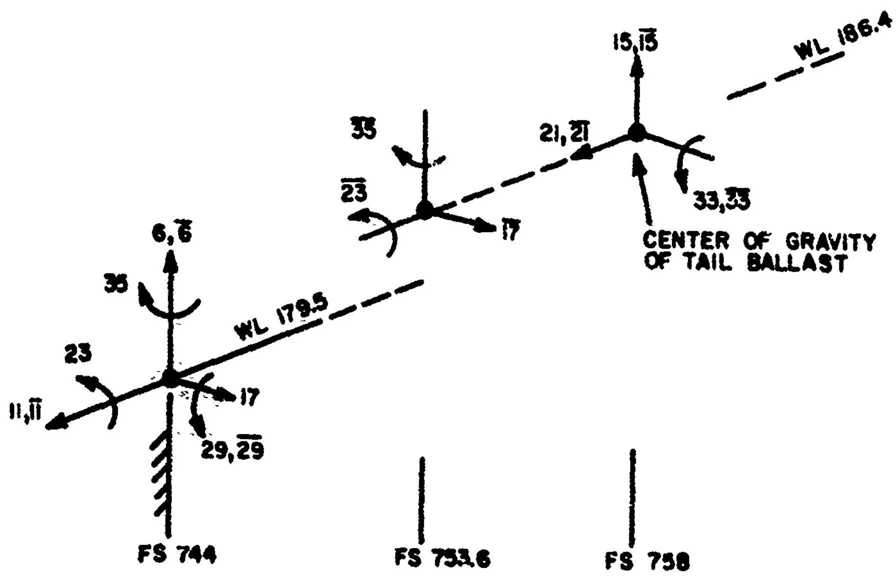


Figure 68 Revised Nose Block Model



(A) ORIGI[illegible] EGREE OF FREEDOM DESIGNATION



(B) REVISED DEGREES OF FREEDOM

Figure 69 Revised Tail Block Model

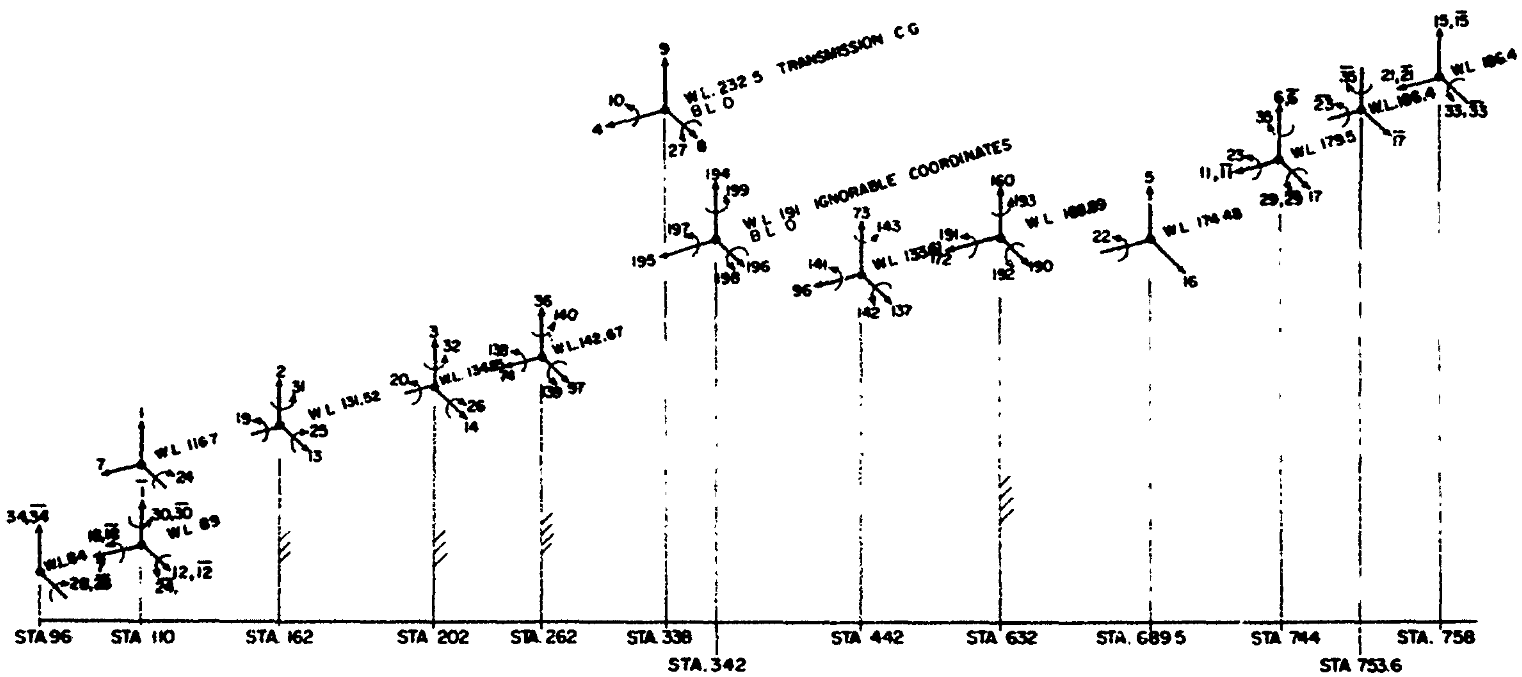
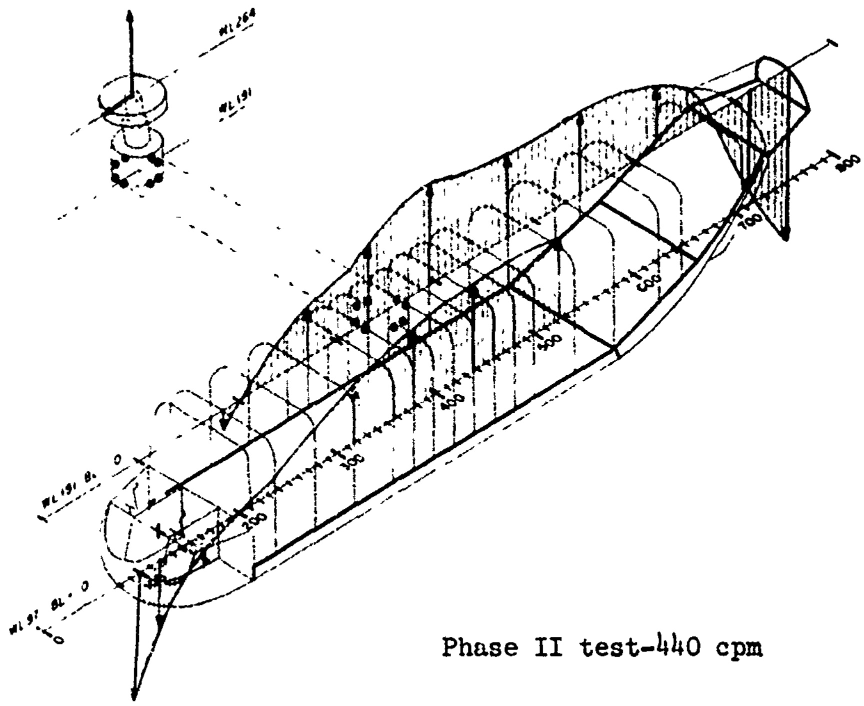
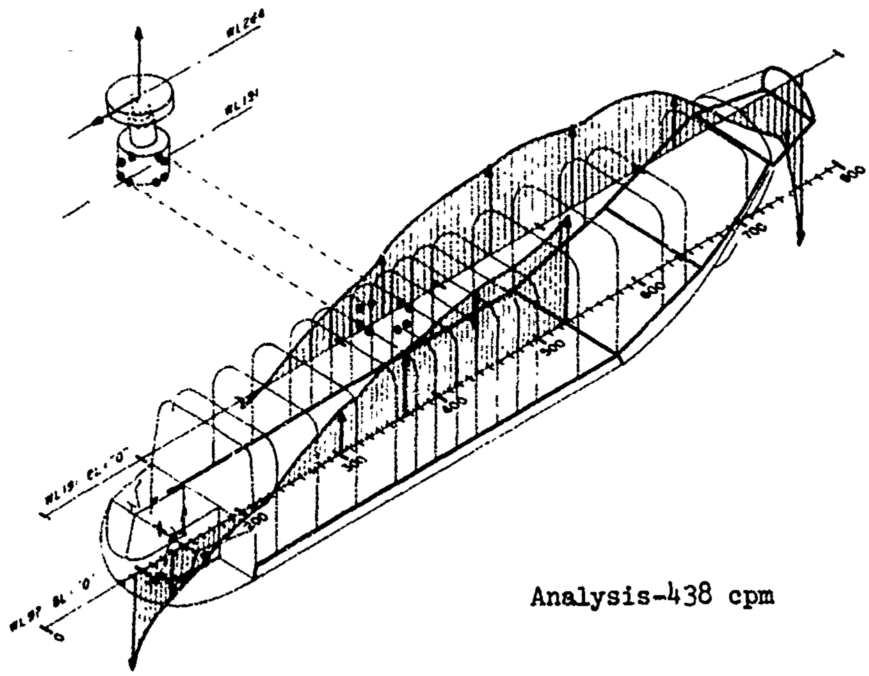


Figure 70 Eighteen Bay model - Phase II
Nose and Tail Ballast Vertical/Lateral Flexibility

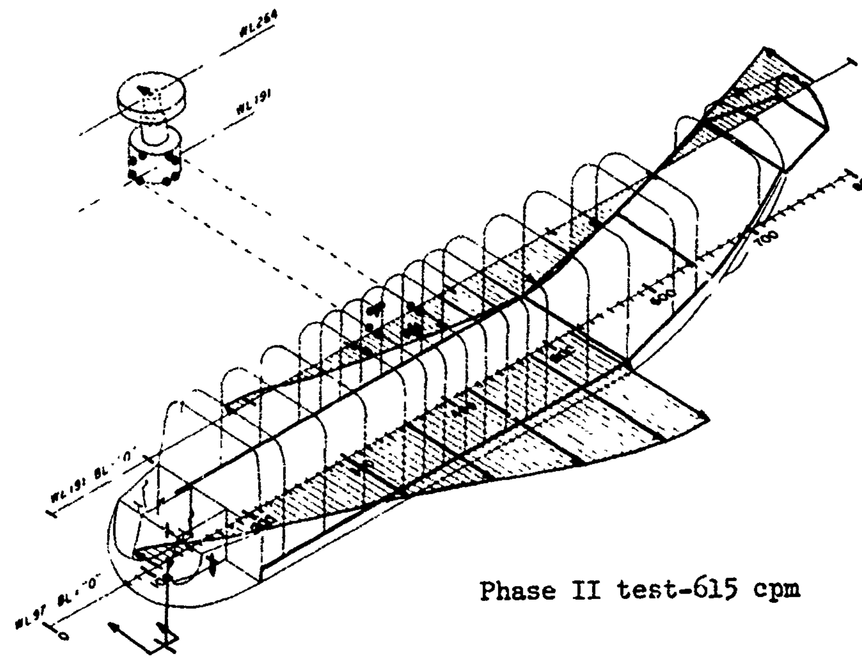


Phase II test-440 cpm

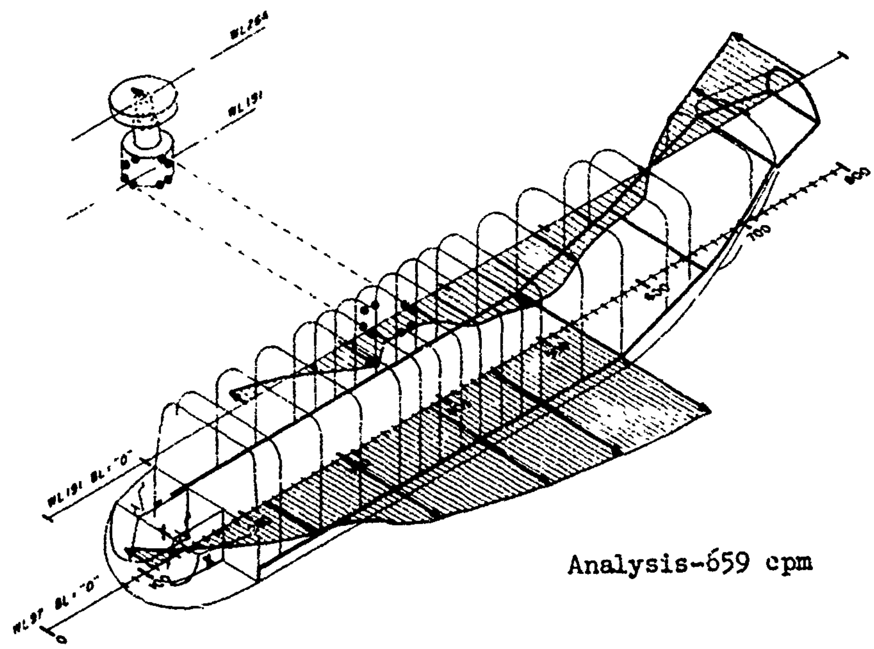


Analysis-438 cpm

Figure 72 Phase II Correlation of First Vertical Bending Mode

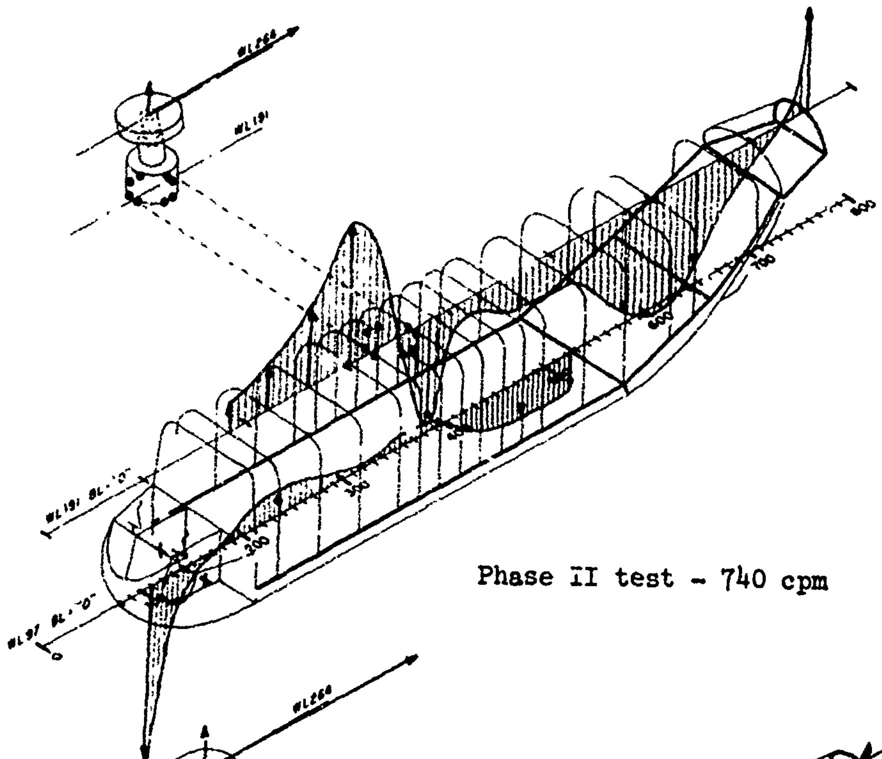


Phase II test-615 cpm

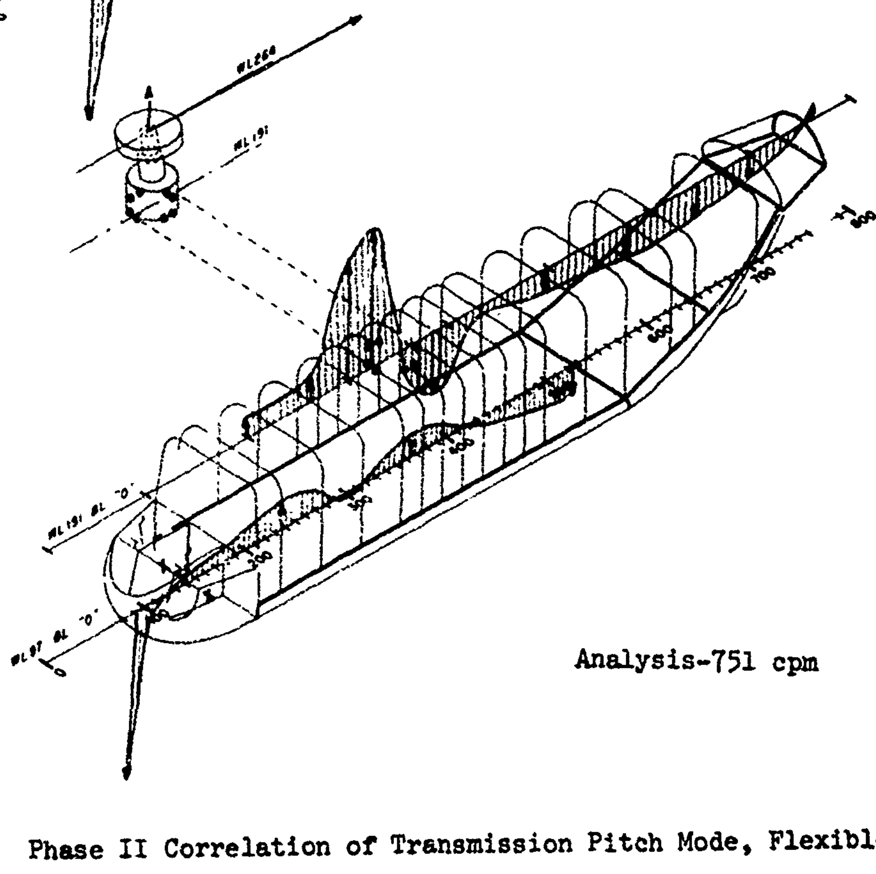


Analysis-659 cpm

Figure 73 Phase II Correlation of First Lateral Bending Mode

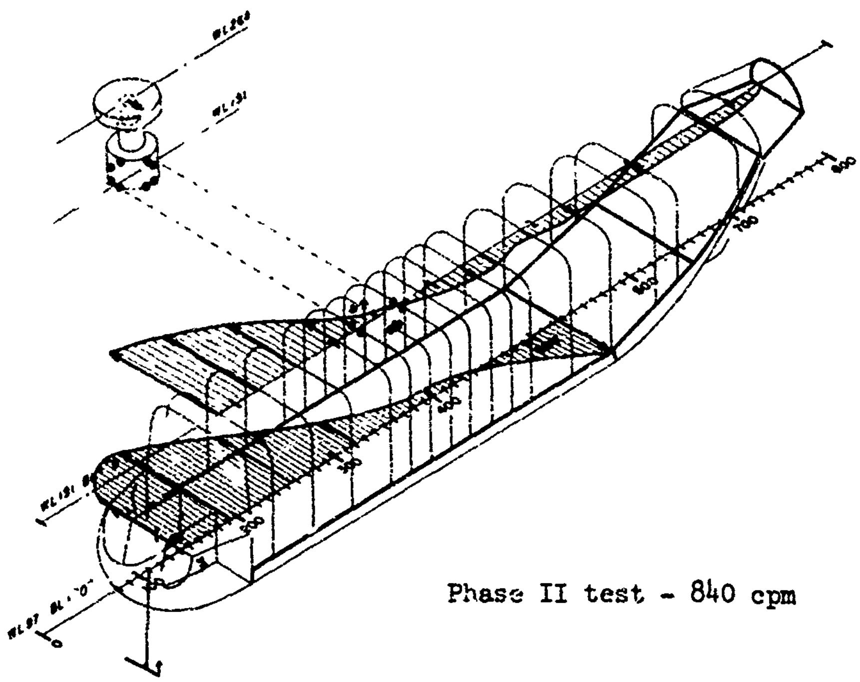


Phase II test - 740 cpm



Analysis-751 cpm

Figure 74 Phase II Correlation of Transmission Pitch Mode, Flexible Ballast



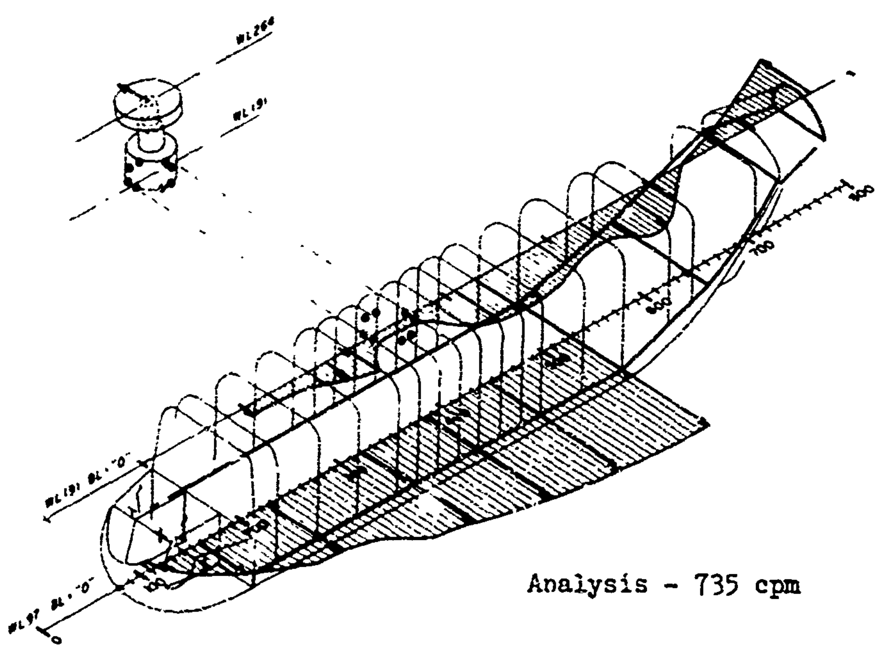


Figure 75 Phase II Correlation of Forward Cabin Lateral Mode, Flexible Ballast Blocks

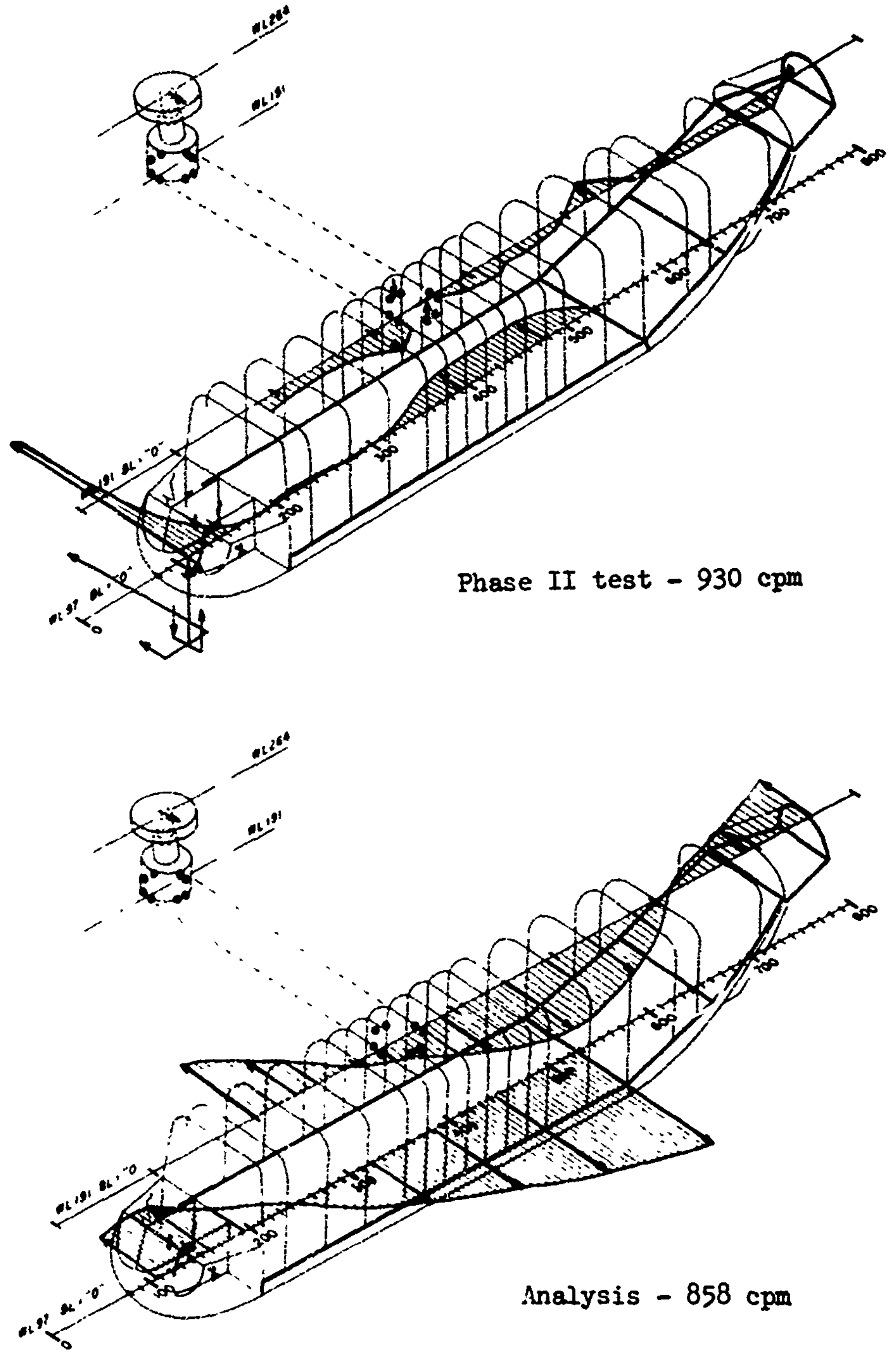


Figure 76 Phase II Correlation of Nose Block Lateral Roll Mode, Flexible Ballast

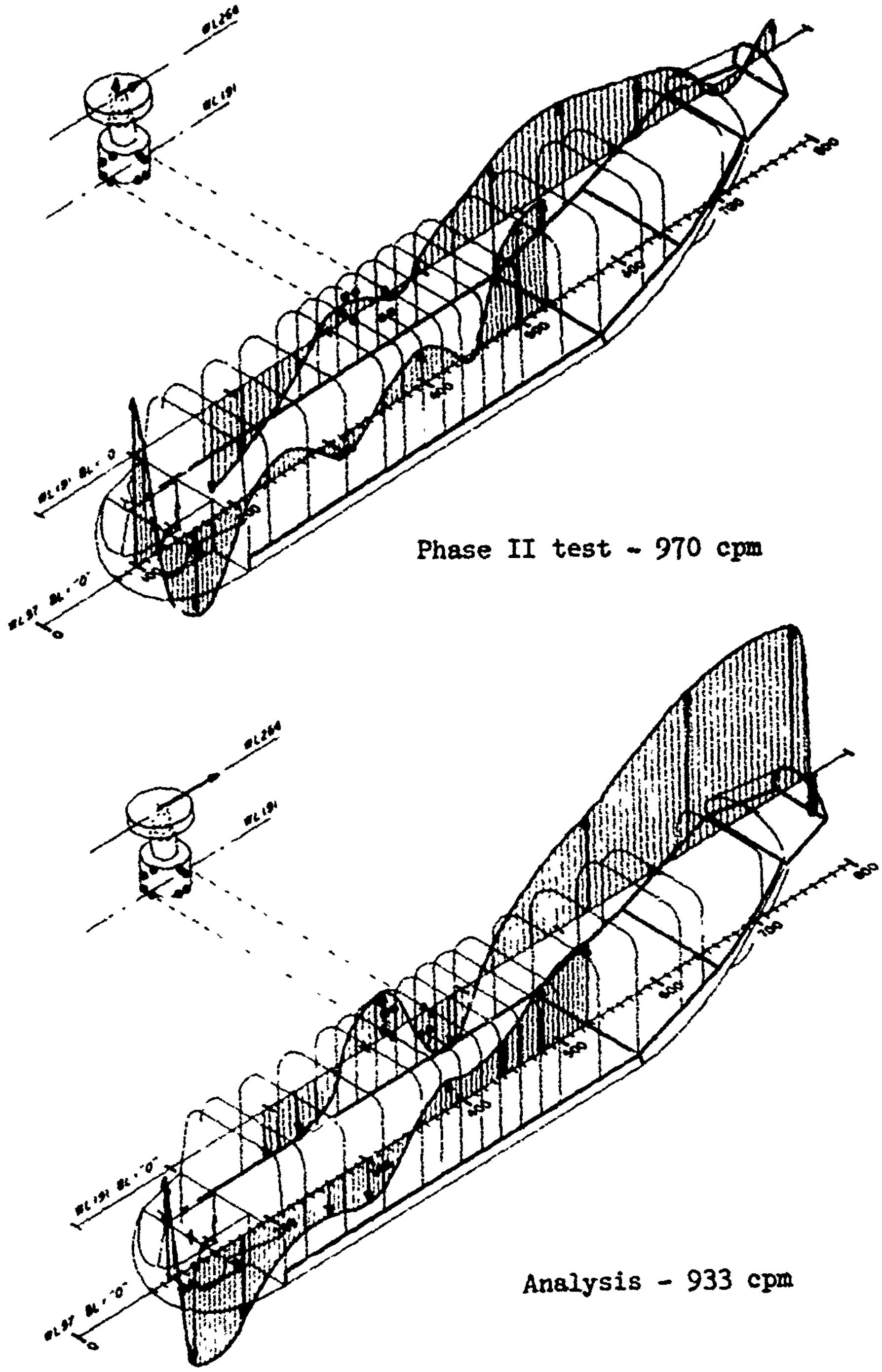
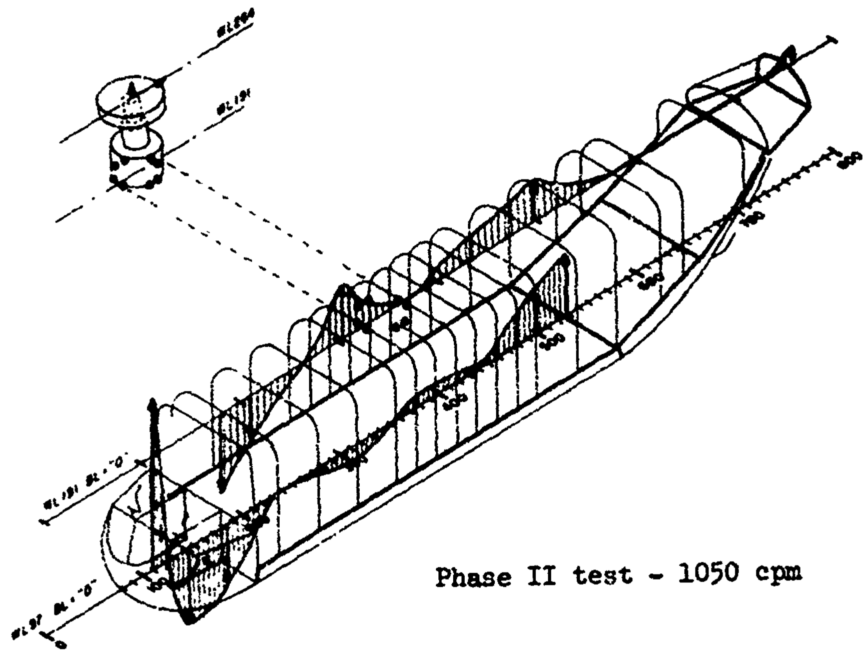
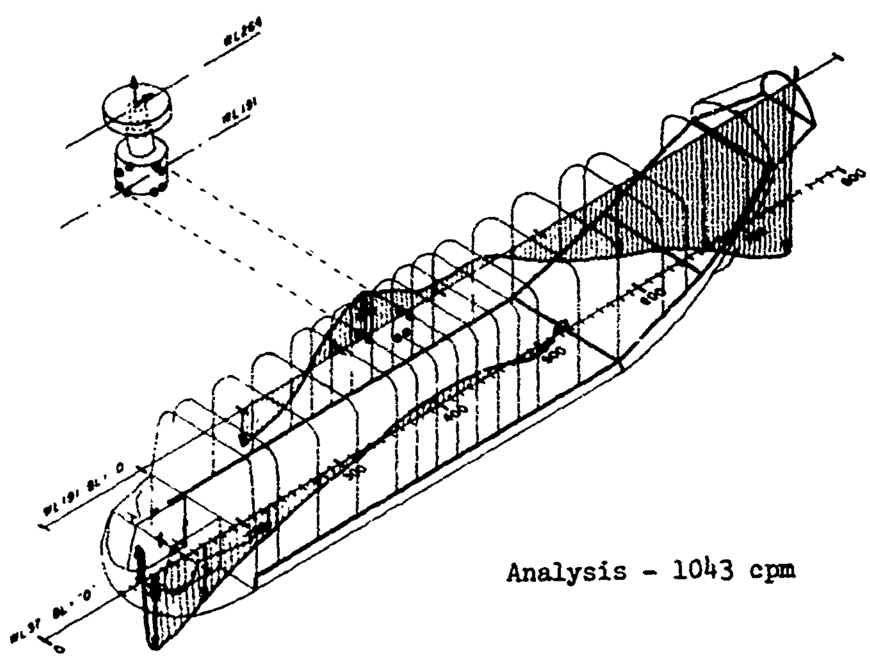


Figure 77 Phase Correlation Nose Block Vertical/Transmission Pitch Mode, Flexible Ballast

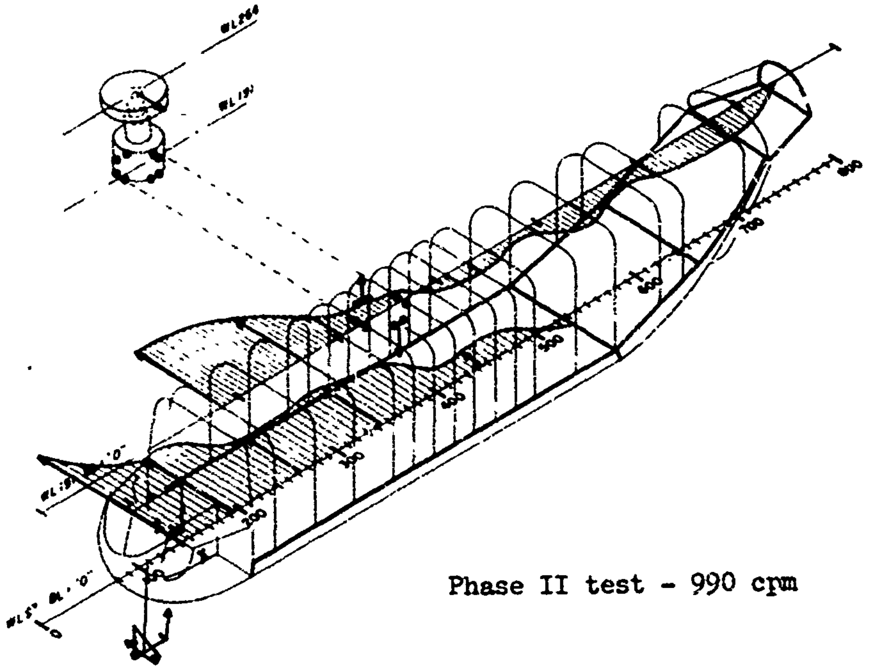


Phase II test - 1050 cpm

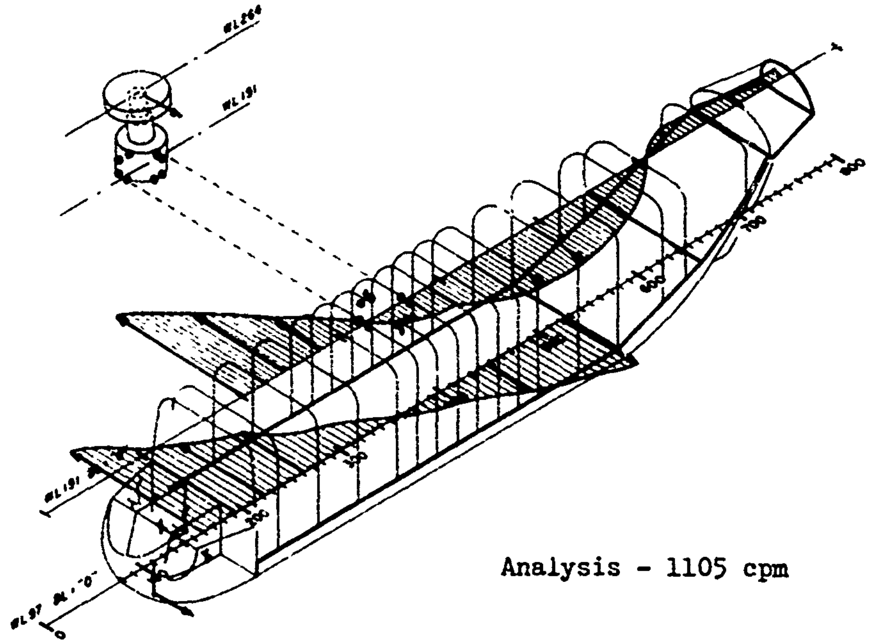


Analysis - 1043 cpm

Figure 78 Phase II Correlation of Nose Block Vertical Mode, Flexible Ballast



Phase II test - 990 cpm



Analysis - 1105 cpm

Figure 79 Phase II Correlation of Forward Cabin/Nose Block Lateral Mode, Rigid Ballast

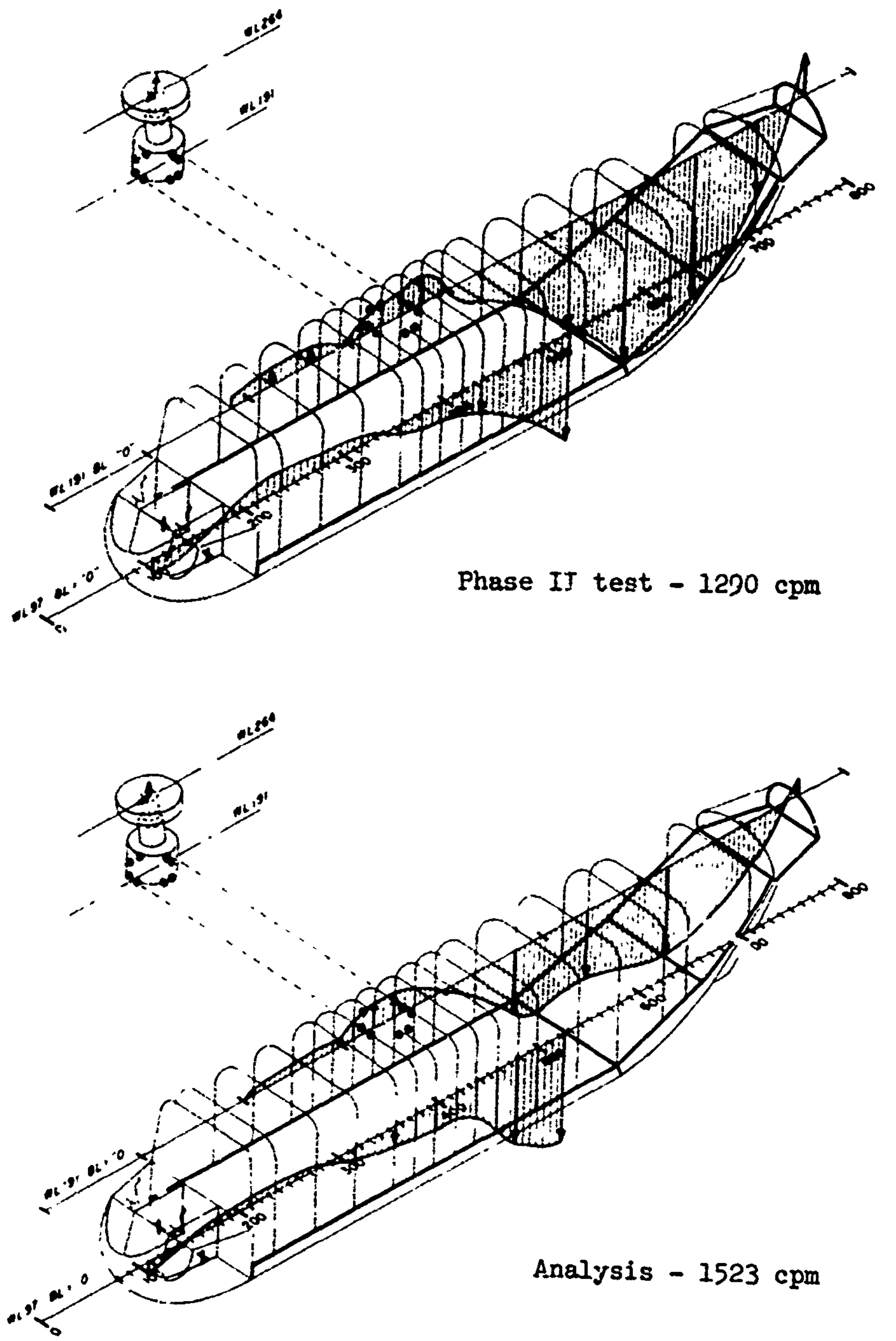
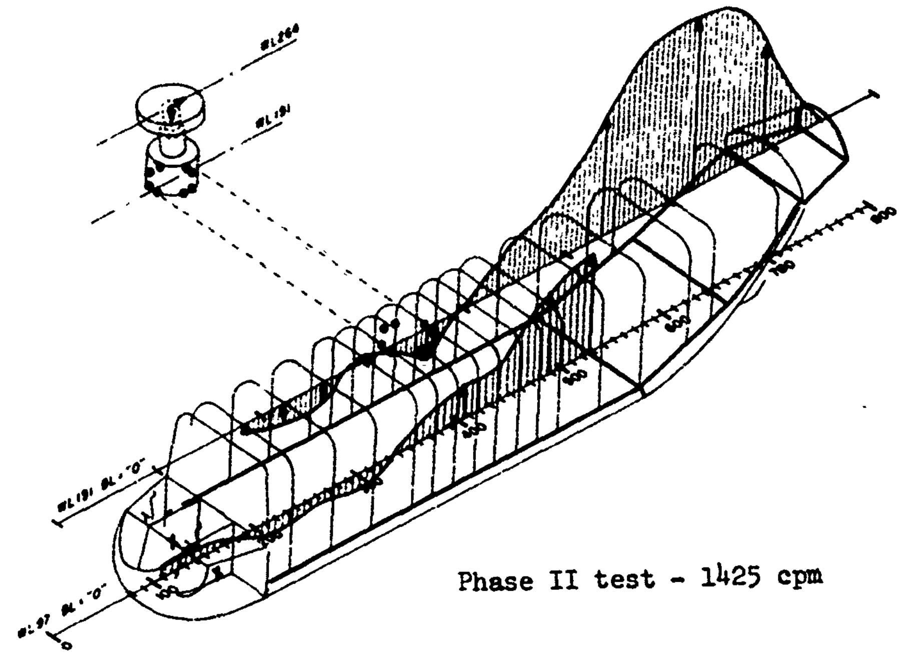


Figure 80 Phase II Correlation of Second Vertical Bending Mode, Rigid Ballast



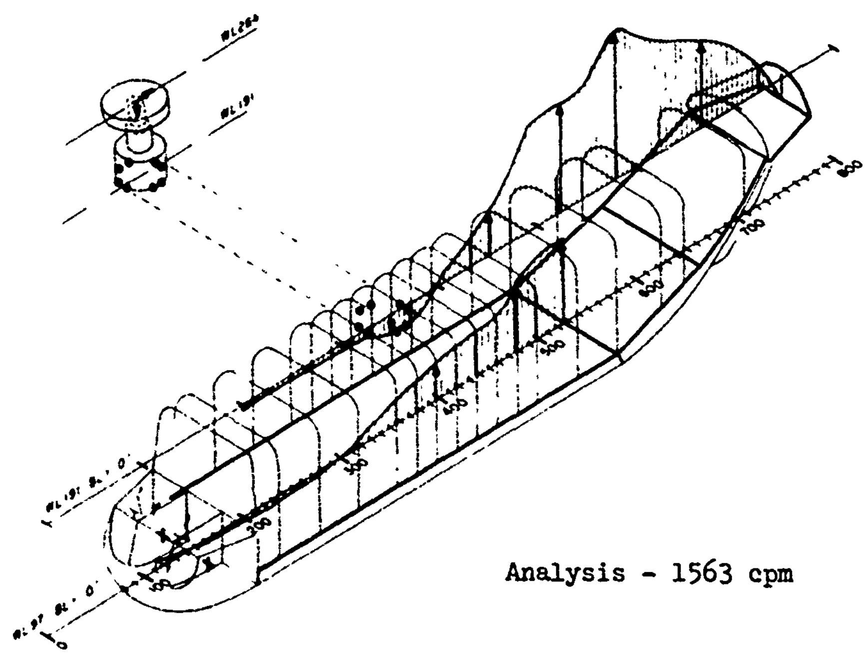
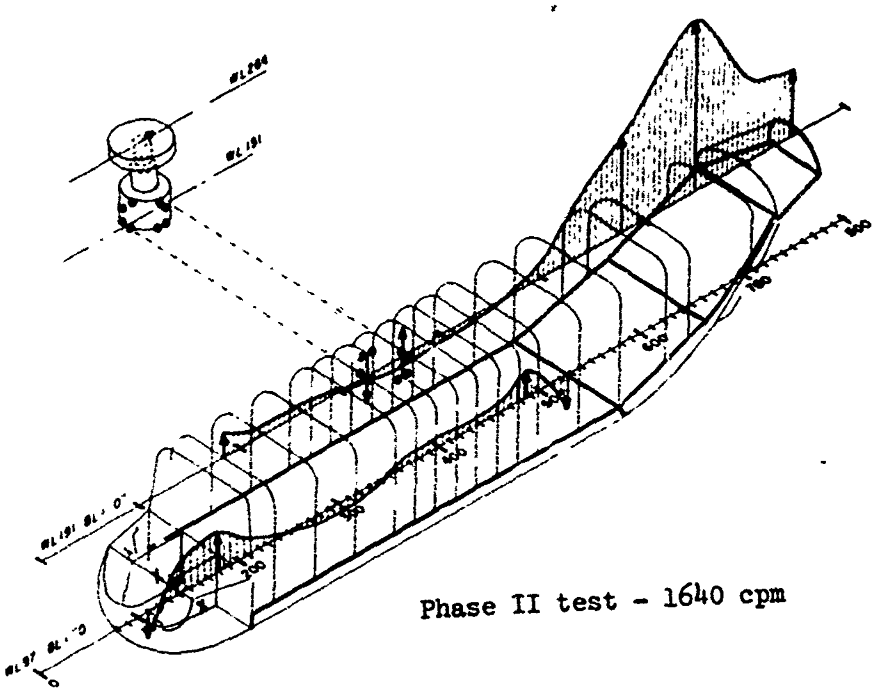
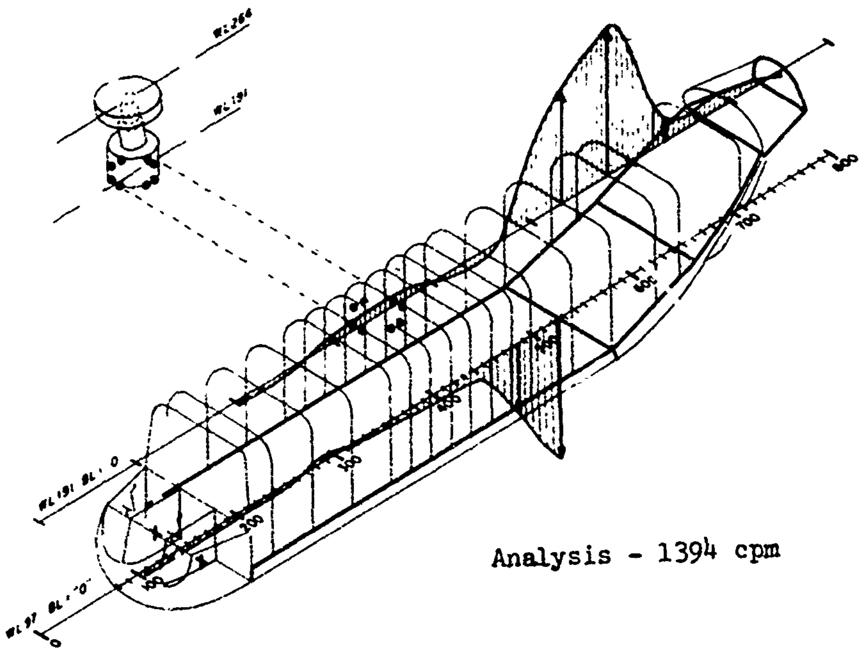


Figure 81 Phase II Correlation of Transmission Vertical/Ramp Vertical Bending Mode, Rigid Ballast

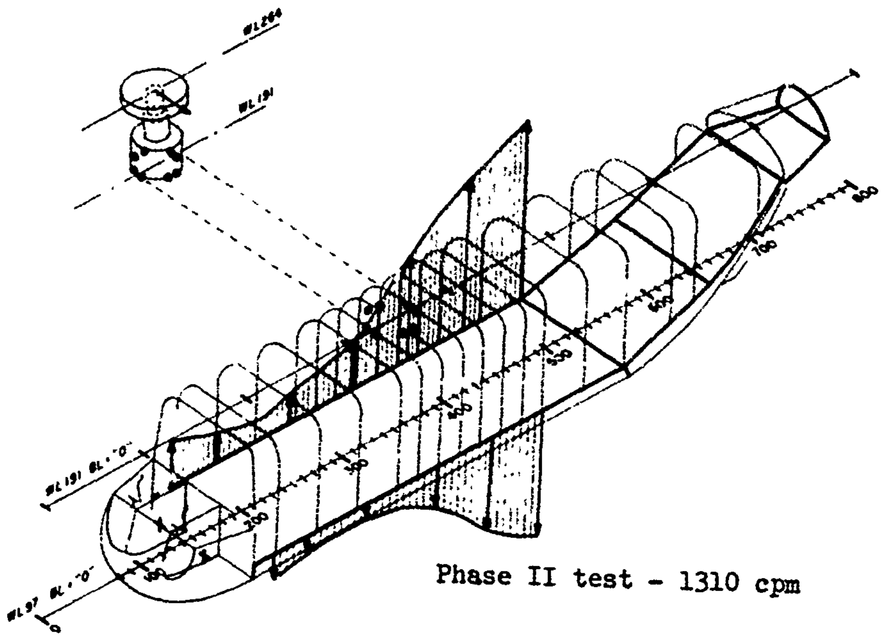


Phase II test - 1640 cpm

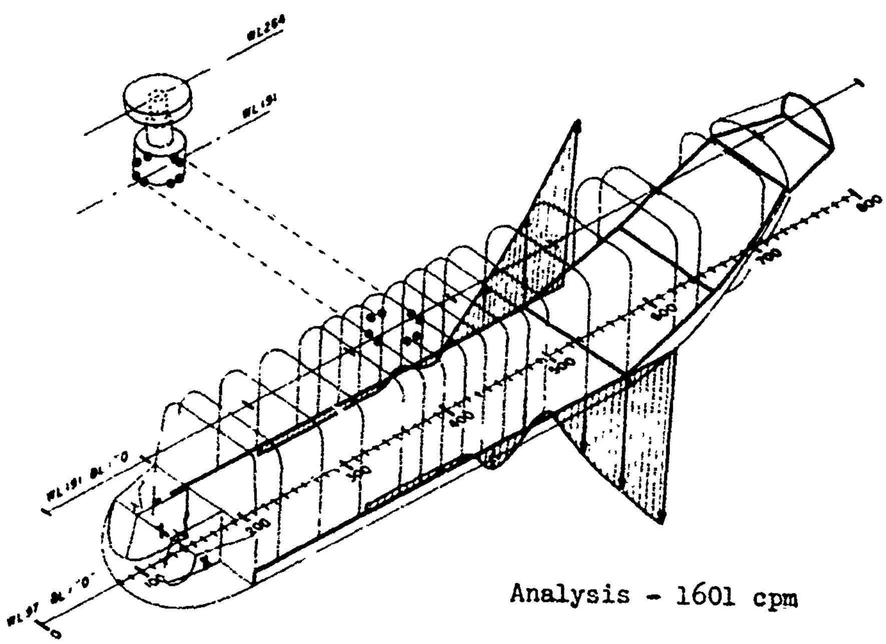


Analysis - 1394 cpm

Figure 82 Phase II Correlation of Ramp Vertical Bending Mode, Rigid Ballast

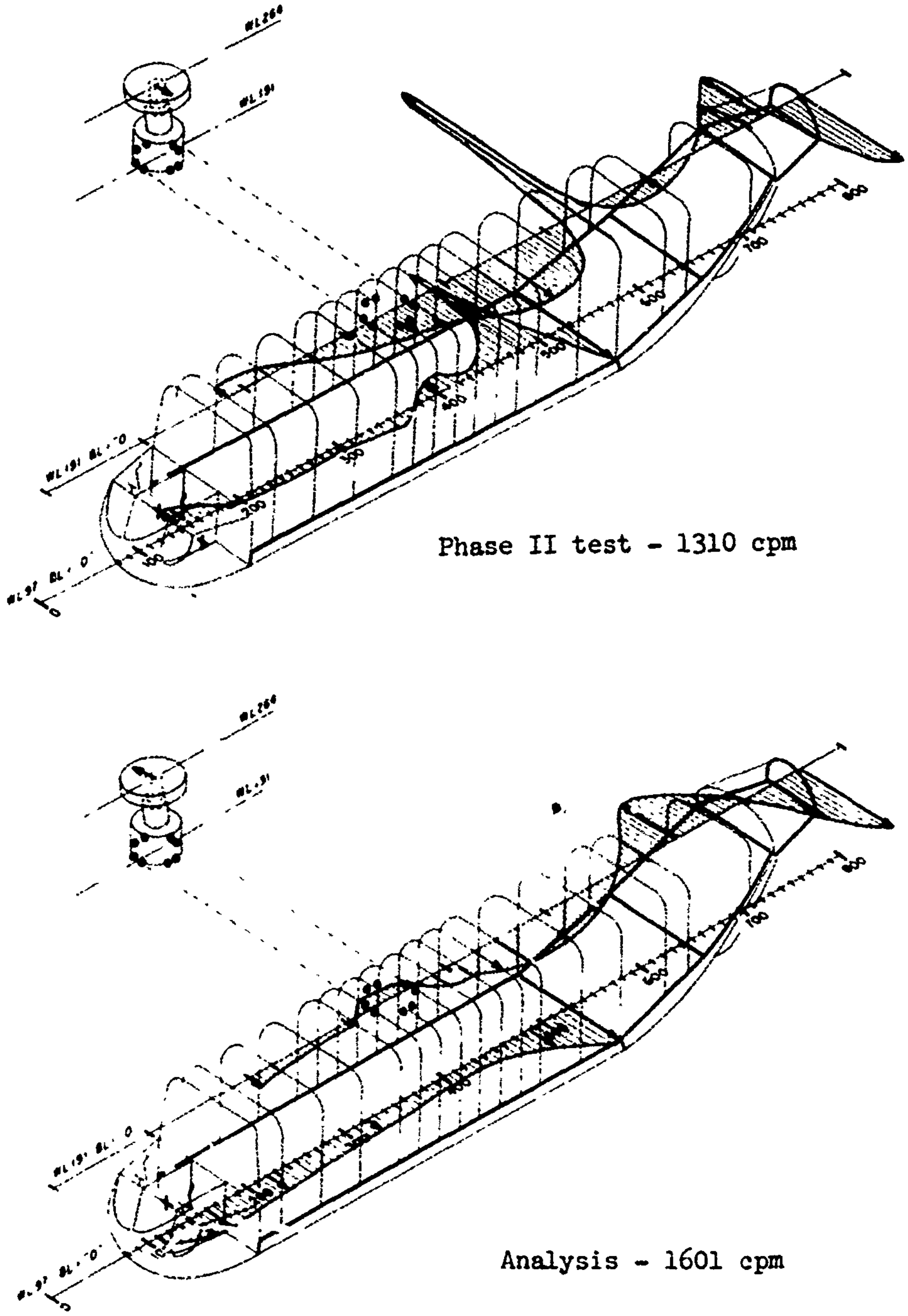


Phase II test - 1310 cpm



Analysis - 1601 cpm

Figure 83 Phase II Correlation of Torsion Mode, Rigid Ballast (Vertical Displacements)



Phase II test - 1310 cpm

Analysis - 1601 cpm

Figure 84 Phase II Correlation of Torsion Mode, Rigid Ballast (Lateral Displacements)

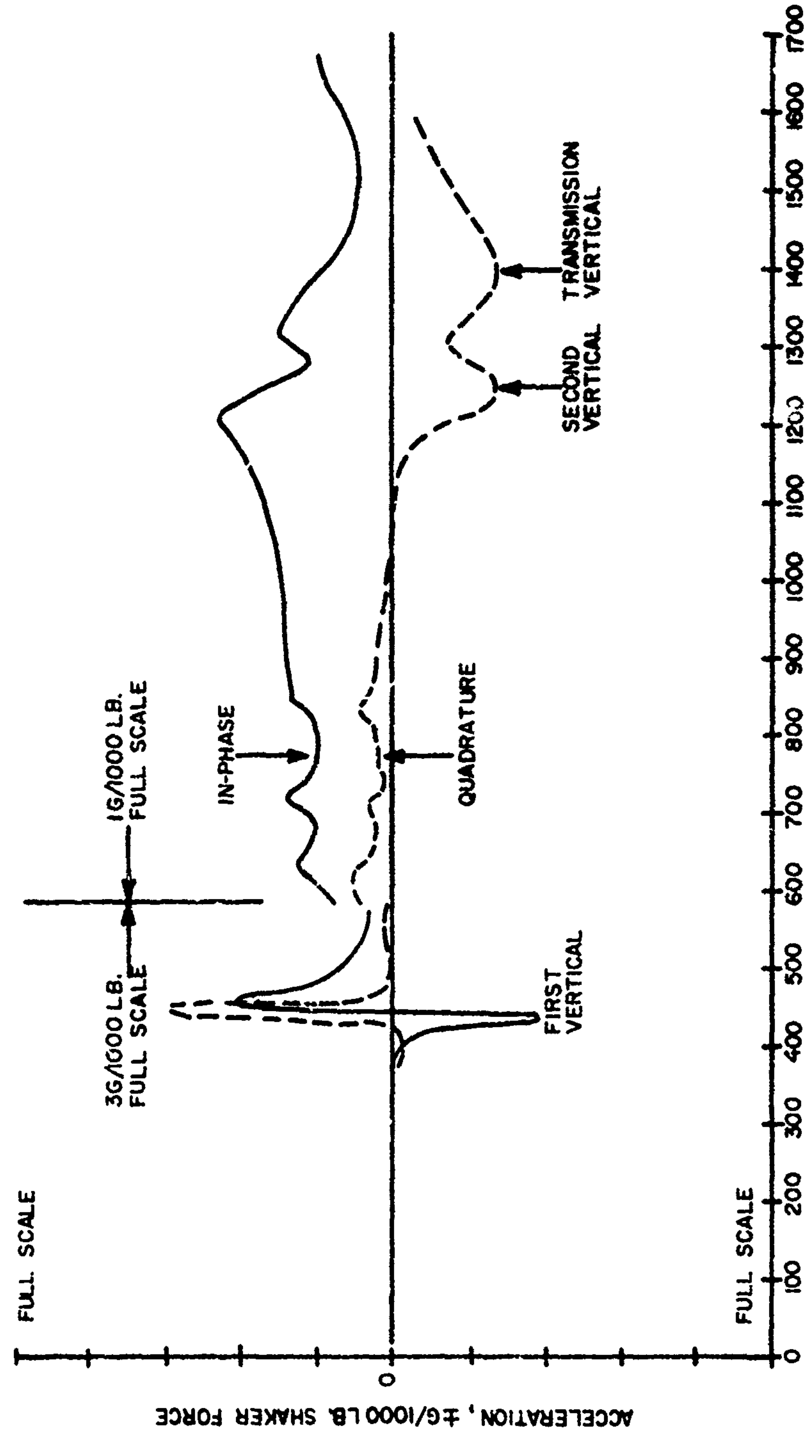


Figure 85 Typical Vertical Response to Vertical Excitation

TABLE 1
STRINGER AND PANEL STRUCTURAL DATA, 62 STRINGER
STRUCTURE, FS 162-262.

F.S. = 162-182.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	.00	191.000	.061	.024
2	-7.00	191.000	.092	.024
3	-13.00	191.000	.092	.024
4	-20.00	191.000	.091	.024
5	-26.00	191.000	.075	.025
6	-31.81	191.000	.075	.025
7	-37.59	187.620	.075	.025
8	-43.50	184.000	.061	.035
9	-47.56	180.000	.061	.035
10	-50.42	174.500	.075	.035
11	-53.00	169.000	.090	.035
12	-53.00	163.000	.174	.063
13	-53.00	157.000	.116	.063
14	-53.00	151.000	.116	.063
15	-53.00	145.000	.116	.063
16	-53.00	139.000	.116	.063
17	-53.00	133.000	.116	.063
18	-53.00	127.000	.530	.046
19	-53.00	121.000	.090	.046
20	-53.00	115.000	.090	.046
21	-53.00	109.000	.090	.071
22	-53.00	103.000	.090	.053
23	-50.84	97.000	.333	.040
24	-48.00	92.000	.075	.040
25	-42.12	88.690	.121	.040
26	-35.70	87.000	.121	.032
27	-29.28	87.000	.121	.032
28	-22.86	87.000	.121	.032
29	-16.44	87.000	.696	.050
30	-10.96	87.000	.163	.063
31	-5.48	87.000	.278	.063
32	.00	87.000	.278	.063
33	5.48	87.000	.278	.063
34	10.96	87.000	.163	.050
35	16.44	87.000	.696	.032
36	22.36	87.000	.121	.032
37	29.28	87.000	.121	.032
38	35.70	87.000	.121	.032
39	42.12	88.690	.121	.032
40	48.00	92.000	.075	.032

TABLE 1 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.84	97.000	.137	.032
42	53.00	103.000	.090	.032
43	53.00	109.000	.090	.032
44	53.00	115.000	.090	.032
45	53.00	121.000	.109	.032
46	53.00	127.000	.532	.032
47	53.00	133.000	.109	.032
48	53.00	139.000	.090	.032
49	53.00	145.000	.090	.032
50	53.00	151.000	.090	.032
51	53.00	157.000	.090	.032
52	53.00	163.000	.116	.032
53	53.00	169.000	.075	.032
54	50.42	174.500	.075	.032
55	47.56	180.000	.075	.032
56	43.50	184.000	.075	.025
57	37.59	187.620	.075	.025
58	31.81	191.000	.075	.025
59	26.00	191.000	.075	.024
60	20.00	191.000	.061	.024
61	13.00	191.000	.061	.024
62	7.00	191.000	.061	.024

TABLE 1 (continued)

F.S. = 182-202.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	.00	191.000	.061	.024
2	-7.00	191.000	.092	.024
3	-13.00	191.000	.092	.024
4	-20.00	191.000	.091	.024
5	-26.00	191.000	.075	.025
6	-31.81	191.000	.075	.025
7	-37.59	187.620	.075	.025
8	-43.50	184.000	.061	.035
9	-47.56	180.000	.061	.035
10	-50.42	174.500	.075	.035
11	-53.00	169.000	.090	.035
12	-53.00	163.000	.174	.000
13	-53.00	157.000	.116	.000
14	-53.00	151.000	.116	.000
15	-53.00	145.000	.116	.000
16	-53.00	139.000	.116	.000
17	-53.00	133.000	.116	.000
18	-53.00	127.000	.530	.000
19	-53.00	121.000	.090	.000
20	-53.00	115.000	.090	.000
21	-53.00	109.000	.090	.000
22	-53.00	103.000	.090	.000
23	-50.84	97.000	.333	.040
24	-48.00	92.000	.075	.040
25	-42.12	88.690	.121	.040
26	-35.70	87.000	.121	.032
27	-29.28	87.000	.121	.032
28	-22.86	87.000	.121	.032
29	-16.44	87.000	.696	.050
30	-10.96	87.000	.163	.063
31	-5.48	87.000	.278	.000
32	.00	87.000	.278	.000
33	5.48	87.000	.278	.063
34	10.96	87.000	.163	.050
35	16.44	87.000	.696	.032
36	22.86	87.000	.121	.032
37	29.28	87.000	.121	.032
38	35.70	87.000	.121	.032
39	42.12	88.690	.121	.032
40	48.00	92.000	.075	.032

TABLE 1 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.84	97.000	.137	.032
42	53.00	103.000	.090	.032
43	53.00	109.000	.090	.032
44	53.00	115.000	.090	.032
45	53.00	121.000	.109	.032
46	53.00	127.000	.532	.032
47	53.00	133.000	.109	.032
48	53.00	139.000	.090	.032
49	53.00	145.000	.090	.032
50	53.00	151.000	.090	.032
51	53.00	157.000	.090	.032
52	53.00	163.000	.116	.032
53	53.00	169.000	.075	.032
54	50.42	174.500	.075	.032
55	4[illegible].56	180.000	.075	.032
56	43.50	184.000	.075	.025
57	37.59	187.620	.075	.025
58	31.81	191.000	.075	.025
59	26.00	191.000	.075	.024
60	20.00	191.000	.061	.024
61	13.00	191.000	.061	.000
62	7.00	191.000	.061	.000

TABLE 1 (continued)

F.S. = 202-222.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	.00	191.000	.061	.024
2	-7.00	191.000	.092	.024
3	-13.00	191.000	.092	.024
4	-20.00	191.000	.091	.024
5	-26.00	191.000	.075	.025
6	-31.81	191.000	.075	.025
7	-37.59	187.620	.075	.025
8	-43.50	184.000	.061	.035
9	-47.56	180.000	.061	.035
10	-50.42	174.500	.075	.035
11	-53.00	169.000	.090	.035
12	-53.00	163.000	.174	.000
13	-53.00	157.000	.116	.000
14	-53.00	151.000	.116	.000
15	-53.00	145.000	.116	.000
16	-53.00	139.000	.116	.000
17	-53.00	133.000	.116	.000
18	-53.00	127.000	.530	.000
19	-53.00	121.000	.090	.000
20	-53.00	115.000	.090	.000
21	-53.00	109.000	.090	.000
22	-53.00	103.000	.090	.000
23	-50.84	97.000	.333	.040
24	-48.00	92.000	.075	.040
25	-42.12	88.690	.121	.040
26	-35.70	87.000	.121	.032
27	-29.28	87.000	.121	.032
28	-22.86	87.000	.121	.032
29	-16.44	87.000	.696	.050
30	-10.96	87.000	.163	.063
31	-5.48	87.000	.278	.050
32	.00	87.000	.278	.050
33	5.48	87.000	.278	.063
34	10.96	87.000	.163	.050
35	16.44	87.000	.696	.032
36	22.86	87.000	.121	.032
37	29.28	87.000	.121	.032
38	35.70	87.000	.121	.032
39	42.12	88.690	.121	.032
40	48.00	92.000	.075	.032

TABLE 1 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.84	97.000	.137	.032
42	53.00	103.000	.090	.032
43	53.00	109.000	.090	.032
44	53.00	115.000	.090	.032
45	53.00	121.000	.109	.032
46	53.00	127.000	.532	.032
47	53.00	133.000	.109	.000
48	53.00	139.000	.090	.000
49	53.00	145.000	.090	.000
50	53.00	151.000	.090	.000
51	53.00	157.000	.090	.000
52	53.00	163.000	.116	.032
53	53.00	169.000	.075	.032
54	50.42	174.500	.075	.032
55	47.56	180.000	.075	.032
56	43.50	184.000	.075	.025
57	37.59	187.620	.075	.025
58	31.81	191.000	.075	.025
59	26.00	191.000	.075	.024
60	20.00	191.000	.061	.024
61	13.00	191.000	.061	.024
62	7.00	191.000	.061	.024

TABLE 1 (continued)

F.S. = 222-242.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	.00	191.000	.061	.024
2	-7.00	191.000	.092	.024
3	-13.00	191.000	.092	.024
4	-20.00	191.000	.091	.024
5	-26.00	191.000	.075	.025
6	-31.81	191.000	.075	.025
7	-37.59	187.620	.075	.025
8	-43.50	184.000	.075	.027
9	-47.56	180.000	.075	.027
10	-50.42	174.500	.075	.027
11	-53.00	169.000	.090	.032
12	-53.00	163.000	.330	.032
13	-53.00	157.000	.078	.032
14	-53.00	151.000	.078	.032
15	-53.00	145.000	.078	.032
16	-53.00	139.000	.078	.032
17	-53.00	133.000	.078	.032
18	-53.00	127.000	.078	.032
19	-53.00	121.000	.078	.032
20	-53.00	115.000	.078	.032
21	-53.00	109.000	.078	.032
22	-53.00	103.000	.078	.032
23	-50.84	97.000	.211	.025
24	-48.00	92.000	.075	.025
25	-42.12	88.690	.121	.025
26	-35.70	87.000	.121	.025
27	-29.28	87.000	.121	.025
28	-22.86	87.000	.121	.025
29	-16.44	87.000	.317	.025
30	-10.96	87.000	.163	.025
31	-5.48	87.000	.121	.025
32	.00	87.000	.121	.025
33	5.48	87.000	.121	.025
34	10.96	87.000	.163	.025
35	16.44	87.000	.317	.025
36	22.86	87.000	.121	.025
37	29.28	87.000	.121	.025
38	35.70	87.000	.121	.025
39	42.12	88.690	.121	.025
40	48.00	92.000	.075	.025

TABLE 1 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.84	97.000	.137	.025
42	53.00	103.000	.090	.025
43	53.00	109.000	.090	.025
44	53.00	115.000	.090	.025
45	53.00	121.000	.109	.025
46	53.00	127.000	.335	.032
47	53.00	133.000	.195	.032
48	53.00	139.000	.078	.032
49	53.00	145.000	.078	.032
50	53.00	151.000	.078	.032
51	53.00	157.000	.078	.032
52	53.00	163.000	.109	.032
53	53.00	169.000	.090	.027
54	50.42	174.500	.075	.027
55	47.56	180.000	.075	.027
56	43.50	184.000	.075	.025
57	37.59	187.620	.075	.025
58	31.81	191.000	.075	.025
59	26.00	191.000	.075	.024
60	20.00	191.000	.061	.024
61	13.00	191.000	.061	.024
62	7.00	191.000	.061	.024

TABLE 1 (continued)

F.S. = 242-262.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	.00	191.000	.061	.024
2	-7.00	191.000	.092	.000
3	-13.00	191.000	.092	.000
4	-20.00	191.000	.091	.024
5	-26.00	191.000	.075	.025
6	-31.81	191.000	.075	.025
7	-37.59	187.620	.075	.025
8	-43.50	184.000	.075	.027
9	-47.56	180.000	.075	.027
10	-50.42	174.500	.075	.027
11	-53.00	169.000	.090	.032
12	-53.00	163.000	.330	.032
13	-53.00	157.000	.078	.032
14	-53.00	151.000	.078	.032
15	-53.00	145.000	.078	.032
16	-53.00	139.000	.078	.032
17	-53.00	133.000	.078	.032
18	-53.00	127.000	.078	.032
19	-53.00	121.000	.078	.032
20	-53.00	115.000	.078	.032
21	-53.00	109.000	.078	.032
22	-53.00	103.000	.078	.032
23	-50.84	97.000	.211	.025
24	-48.00	92.000	.075	.025
25	-42.12	88.690	.121	.025
26	-35.70	87.000	.121	.025
27	-29.28	87.000	.121	.025
28	-22.86	87.000	.121	.025
29	-16.44	87.000	.317	.025
30	-10.96	87.000	.163	.025
31	-5.48	87.000	.121	.025
32	.00	87.000	.121	.025
33	5.48	87.000	.121	.025
34	10.96	87.000	.163	.025
35	16.44	87.000	.317	.025
36	22.86	87.000	.121	.025
37	29.28	87.000	.121	.025
38	35.70	87.000	.121	.025
39	42.12	88.690	.121	.025
40	48.00	92.000	.075	.025

TABLE 1 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.84	97.000	.137	.025
42	53.00	103.000	.090	.025
43	53.00	109.000	.090	.025
44	53.00	115.000	.090	.025
45	53.00	121.000	.109	.025
46	53.00	127.000	.335	.032
47	53.00	133.000	.195	.032
48	53.00	139.000	.078	.032
49	53.00	145.000	.078	.032
50	53.00	151.000	.078	.032
51	53.00	157.000	.078	.032
52	53.00	163.000	.109	.032
53	53.00	169.000	.090	.027
54	50.42	174.500	.075	.027
55	47.56	180.000	.075	.027
56	43.50	184.000	.075	.025
57	37.59	187.620	.075	.025
58	31.81	191.000	.075	.025
59	26.00	191.000	.075	.024
60	20.00	191.000	.061	.024
61	13.00	191.000	.061	.024
62	7.00	191.000	.061	.024

TABLE 2
STRINGER AND PANEL STRUCTURAL DATA, 62 STRINGER STRUCTURE, FS 262-442.

STR.#	F.S. Y B.L.	Z W.L.	PANEL WIDTH ℓ(in)	262–282 t	262–282 A	282–302 t	282–302 A	302–322 t	302–322 A	322–342 t	322–342 A	342–362 t	342–362 A	362–382 t	362–382 A	382–402 t	382–402 A	402–422 t	402–422 A	422–442 t	422–442 A
1	0.	191.0	7.0	.025	.0648	.025	.0804	.04	.0804	0.	0.	0.	0.	.032	.0442	.025	.1004	.025	.0804	.025	.0804
2	-7.0	191.0	6.0	.025	.5123	.025	.467	.04	1.31	0.	0.	0.	0.	.050	1.085	.025	.2975	.025	.0874	.025	.3024
3	-13.0	191.0	7.0	.025	.767	.025	.086	.04	.0828	0.	0.	0.	0.	.05	.072	.025	.260	.025	.0804	.025	.0804
4	-20.0	191.0	6.0	.025	.556	.025	.425	.04	.9262	.04	2.768	.04	2.768	.04	.958	.025	.205	.025	.1484	.025	.1484
5	-26.0	190.76	5.91	.025	.7157	.025	.1497	.04	.2074	.04	.2312	.04	.2312	.04	.144	.025	.176	.025	.148	.025	.148
6	-31.81	190.7	6.14	.025	.1497	.025	.1497	.04	.1612	.04	.1476	.04	.1476	.032	.176	.025	.176	.025	.148	.025	.148
7	-37.59	187.67	6.93	.025	.1497	.025	.1497	.04	.1612	.04	.1476	.04	.1476	.032	.284	.032	.148	.032	.148	.025	.148
8	-43.5	184.0	5.70	.027	.2244	.027	.2083	.048	.4205	.048	.1606	.04	.1484	.032	.109	.032	.0804	.032	.0804	.025	.0804
9	-47.56	180.0	6.20	.027	.0648	.04	.0648	.048	.098	.048	.0886	.04	.0924	.04	.31	.032	.1284	.046	.1004	.025	.0804
10	-50.42	174.5	5.58	.027	.0648	.04	.0648	.048	.096	.048	.0886	.04	.0924	.04	.104	.032	.0995	.03	.0995	.025	.0995
11	-51.38	169.0	6.03	.032	.123	.032	.1184	.032	.15	.05	.0924	.04	.0907	.04	.108	.032	.0995	.046	.0995	.032	.0995
12	-52.08	163.0	6.02	.032	.2487	.032	.3887	0.	.625	.032	.25	.032	.145	.04	.11	.046	.1535	0.	.1979	.032	.332
13	-52.38	157.0	6.01	.032	.0804	.032	.0874	0.	0.	.032	.156	.032	.078	.04	.09	.025	.0995	0.	0.	.04	.1465
14	-52.64	151.0	6.	.032	.0804	.032	.0804	0.	0.	.032	.078	.032	.078	.032	.096	.045	.092	0.	0.	.04	.0995
15	-52.82	145.0	6.	.032	.0804	.032	.0874	0.	0.	.032	.078	.032	.078	.032	.135	.04	.1055	0.	0.	.04	.0995
16	-52.91	139.0	6.	.032	.2499	.032	.3624	.032	.4104	.05	.197	.04	.11	.032	.078	.04	.1465	.04	.1465	.032	.2483
17	-52.98	133.0	6.	.032	.0804	.032	.0504	.032	.2488	.05	.150	.04	.127	.032	.072	.04	.0995	.04	.0995	.032	.0995
18	-53.0	127.0	6.	.032	.1284	.032	.1284	.032	.1284	.032	.164	.032	.141	.032	.072	.04	.1970	.04	.1970	.04	.1970
19	-52.96	121.0	6.	.032	.0804	.032	.0804	.032	.1584	.032	.170	.032	.157	.032	.072	.04	.0995	.04	.0995	.04	.0995
20	-52.94	115.0	6.01	.032	.0804	.032	.0804	.032	.1554	.032	.157	.032	.157	.032	.072	.04	.0995	.05	.0995	.05	.0995
21	-52.57	109.0	6.03	.032	.0804	.032	.0804	.032	.4314	.032	.162	.032	.102	.032	.072	.04	.0995	.04	.0995	.05	.4285
22	-52.31	103.0	6.11	.032	.0504	.032	.0504	.032	.1804	.032	.197	.032	.171	.032	.109	.04	.1435	.04	.1435	.05	.1545
23	-50.84	97.0	5.75	.025	.2716	.025	.3596	.025	.2716	.025	.498	.025	.498	.032	.405	.04	.3671	.04	.3731	.04	.3791
24	-48.0	92.0	6.75	.025	.0624	.025	.1432	.025	.0928	.025	.105	.025	.105	.032	.095	.04	.8662	.032	.9232	.032	.9822
25	-42.12	88.68	6.52	.025	.1064	.025	.1064	.025	.1064	.025	.11	.025	.11	.032	.122	.032	.1064	.032	.1064	.032	.1064
26	-35.7	87.55	6.43	.025	.1064	.025	.1064	.025	.1064	.025.	.11	.025	.11	.032	.10	.032	.1064	.032	.1064	.032	.1064
27	-29.28	87.13	6.42	.025	.1064	.025	.1064	.025	.1064	.025	.110	.025	.11	.032	.10	.032	.1064	.032	.1064	.032	.1064
28	-22.86	87.01	6.42	.025	.1439	.025	.1439	.025	.1439	.025	.119	.025	.119	.025	.148	0.	.1946	.025	.1544	.025	.1544
29	-16.44	87.0	5.48	.025	.1064	.025	.1064	.025	.1064	.025	.119	.025	.119	.025	.10	.025	.1744	0.	.1895	.025	.1895
30	-10.96	87.0	6.34	.025	.1064	.025	.1064	.025	.1064	.025	.119	.025	.119	.025	.10	.025	.1064	0.	.1064	.025	.1064
31	-4.62	87.0	4.62	.025	.1064	.025	.1064	.025	2.1	0.	3.6	.041	1.672	.05	.10	.025	.1064	0.	.1064	.025	.1064
32	0.0	87.0	5.48	.025	.1064	.025	.1064	.025	.1064	0.0	0.	.041	.84	.05	.84	.020	.1064	0.	.1064	.025	.1064
33	5.48	87.0	5.48	.025	.1064	.025	.1064	.025	.1064	0.0	0.	.025	.11	.025	.10	.025	.1064	0.	.1064	.025	.1064
34	10.96	87.0	5.48	.025	.1064	.025	.1064	.025	.1064	0.0	.125	.025	.11	.025	.10	.025	.1064	0.	.1064	.025	.1064
35	16.44	87.0	5.48	.025	.1064	.025	.1064	.025	.1064	0.0	0.	.025	.11	.025	.10	.025	.1494	.025	.1695	.025	.1695
36	22.86	87.01	3.0	.025	.1439	.025	.1439	.025	.1439	.025	.297	.025	.11	.032	.148	.032	.1544	.025	.1544	.025	.1544
37	29.28	87.22	9.84	.025	.1064	.025	.1064	.025	.1064	.025	.119	.025	.119	.032	.10	.032	.1064	.032	.1064	.032	.1064
38	35.40	87.55	6.52	.025	.1064	.025	.1064	.025	.1064	.025	.119	.025	.119	.032	.10	.032	.1064	.032	.1064	.032	.1064
39	42.12	88.69	6.75	.025	.1064	.025	.1064	.025	.1064	.025	.149	.025	.119	.032	.122	.04	.1064	.032	.1064	.032	.1064
40	48.0	92.0	5.75	.025	.0624	.025	.2145	.025	.0928	.025	.105	.025	.105	.032	.095	.04	.8662	.04	.9222	.04	.9522
41	50.76	97.0	6.11	.025	.2666	.025	.3134	.045	.2666	.032	.498	.032	.498	.032	.4053	.04	.3871	.04	.3731	.05	.3791
42	52.02	103.0	6.03	.025	.0804	.025	.0804	.032	.1934	.032	.195	.032	.169	.032	.09	.04	.1435	.04	.1435	.05	.1545
43	52.58	109.0	6.01	.025	.0804	.025	.0804	.032	.4574	.032	.173	.032	.084	.032	.072	.04	.0995	.05	.0995	.05	.0995
44	52.84	115.0	6.	.025	.0804	.025	.0804	.032	.1678	.032	.155	.032	.155	.032	.072	.04	.0995	.04	.0995	.04	.0995
45	52.97	121.0	6.	.025	.0804	.025	.0804	.032	.1678	.032	.168	.032	.155	.032	.072	.04	.0995	.04	.0995	.04	.0995
46	53.0	127.0	6.	.032	.1204	.032	.1204	.032	.1866	.05	.162	.04	.139	.032	.072	.04	.1970	.04	.1970	.032	.1970
47	52.98	133.0	6.	.032	.0804	.032	.0804	.032	.2898	.05	.15	.04	.127	.032	.072	.04	.0995	.05	.0995	.032	.0995
48	52.92	139.0	6.	.032	.2499	.032	.3624	0.	.4104	.032	.197	.032	.11	.032	.078	.04	.1465	0.	.1465	.05	.2483

TABLE 2 (continued)

STR.#	Y B.L	Z W.L.	PANEL WIDTH (in)	F.S 262–282		282–302		302–322		322–342		342–362		362–382		382–402		402–422		422–442	
				t	A	t	A	t	A	t	A	t	A	t	A	t	A	t	A	t	A
49	52.82	145.0	6.	.032	.0804	.032	.0804	0.	0.	.032	.078	.032	.078	.040	.144	.052	.1695	0.	0.	.05	.0995
50	52.64	151.0	6.01	.032	.0804	.032	.0804	0.	0.	.032	.078	.032	.078	.05	.097	.028	.091	0.	0.	.05	.0995
51	52.38	157.0	6.01	.032	.0804	.032	.0804	0.	0.	.032	.156	.032	.078	.04	.09	.056	.0995	0.	0.	.032	.1565
52	51.98	163.0	6.03	.032	.2487	.032	.3987	.032	.625	.05	.25	.04	.145	.04	.11	.04	.1435	.052	.1979	.032	.332
53	51.38	169.0	5.58	.027	.127	.04	.0834	.048	.156	.040	.0924	.04	.0907	.04	.108	.04	.0995	.025	.0995	.025	.0995
54	50.42	174.7	6.2	.027	.0648	.04	.0648	.048	.096	.048	.1087	.04	.1135	.04	.104	.04	.0995	.051	.0995	.025	.0995
55	47.46	180.0	5.7	.027	.0648	.027	.0648	.048	.098	.048	.1057	.04	.1135	.04	.31	.032	.1052	.032	.1504	.025	.0804
56	43.50	184.0	6.93	.025	.2204	.025	.2133	.040	.4135	.04	.1087	.04	.1735	.04	.105	.032	.0804	.032	.0804	.025	.0804
57	37.59	187.62	6.14	.025	.1497	.025	.1497	.040	.1612	.04	.1476	.04	.1476	.032	.284	.032	.148	.025	.148	.025	.148
58	31.81	189.7	5.91	.025	.1497	.025	.1497	.040	.1612	.04	.1476	.04	.1476	.032	.116	.025	.148	.025	.148	.025	.148
59	26.0	190.76	6.0	.025	.2157	.025	.1497	.050	.2074	.04	.2312	.04	.2312	.04	.144	.025	.176	.025	.1484	.025	.148
60	20.0	191.0	7.0	.025	.4193	.025	.5437	.050	.9726	0.	2.8368	0.	2.8368	.05	.758	.025	.205	.025	.1484	.025	.1484
61	13.0	191.0	6.0	.025	.1725	.025	.0995	.050	.1459	0.	0.	0.	0.	.05	.072	.025	.118	.025	.0804	.025	.0804
62	7.0	191.0	7.0	.025	.5004	.025	.2954	.04	1.1134	0.	0.	0.	0.	.032	1.035	.025	.3175	.025	.1504	.025	.3004

TABLE 3
STRINGER AND PANEL STRUCTURAL DATA, 62 STRINGER
STRUCTURE, FS 442 -522

F.S. = 442-462.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	-.00	191.000	.063	.025
2	-6.75	191.000	.078	.025
3	-13.25	191.000	.078	.025
4	-20.00	191.000	.078	.025
5	-26.00	190.760	.078	.025
6	-31.81	189.700	.078	.025
7	-37.59	187.620	.078	.025
8	-43.50	184.000	.063	.025
9	-47.56	180.000	.078	.025
10	-50.42	174.500	.078	.025
11	-51.38	169.000	.078	.025
12	-51.98	163.000	.078	.032
13	-52.38	157.000	.063	.032
14	-52.64	151.000	.063	.032
15	-52.81	145.000	.063	.032
16	-52.91	139.000	.078	.025
17	-52.98	133.000	.078	.025
18	-53.00	127.000	.078	.025
19	-52.96	121.000	.078	.025
20	-52.94	115.000	.078	.025
21	-52.57	109.000	.078	.032
22	-52.01	103.000	.078	.025
23	-50.79	97.000	.078	.025
24	-48.00	92.000	.100	.025
25	-42.12	88.687	.100	.025
26	-35.70	87.555	.100	.025
27	-29.28	87.125	.100	.025
28	-22.86	87.010	.100	.025
29	-16.44	87.000	.100	.025
30	-10.96	87.000	.100	.025
31	5.48	87.000	.100	.025
32	.00	87.000	.100	.025
33	5.48	87.000	.100	.025
34	10.96	87.000	.100	.025
35	16.44	87.000	.100	.025
36	22.86	87.010	.100	.025
37	29.28	87.125	.100	.025
38	35.70	87.555	.100	.025
39	42.12	88.687	.100	.025
40	48.00	92.000	.100	.025

TABLE 3 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.79	97.000	.078	.025
42	52.01	103.000	.078	.032
43	52.57	109.000	.078	.025
44	52.94	115.000	.078	.025
45	52.96	121.000	.078	.025
46	53.00	127.000	.078	.025
47	52.98	133.000	.078	.025
48	52.91	139.000	.078	.032
49	52.81	145.000	.063	.032
50	52.64	151.000	.063	.032
51	52.37	157.000	.063	.032
52	51.98	163.000	.078	.025
53	51.38	169.000	.063	.025
54	50.42	174.500	.078	.025
55	47.56	180.000	.063	.025
56	43.50	184.000	.078	.025
57	37.59	187.620	.078	.025
58	31.81	189.700	.078	.025
59	26.00	190.760	.078	.025
60	20.00	191.000	.078	.025
61	13.25	191.000	.078	.025
62	6.75	191.000	.078	.025

TABLE 3 (continued)

F.S. = 462-482.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	-.00	191.000	.063	.025
2	-6.75	191.000	.078	.025
3	-13.25	191.000	.078	.025
4	-20.00	191.000	.078	.025
5	-26.00	190.760	.078	.025
6	-31.81	189.700	.078	.025
7	-37.59	187.620	.078	.025
8	-43.50	184.000	.063	.025
9	-47.56	180.000	.078	.025
10	-50.42	174.500	.078	.025
11	-51.38	169.000	.078	.032
12	-51.98	163.000	.078	.032
13	-52.38	157.000	.063	.032
14	-52.64	151.000	.063	.032
15	-52.81	145.000	.063	.032
16	-52.91	139.000	.078	.032
17	-52.98	133.000	.078	.032
18	-53.00	127.000	.078	.025
19	-52.96	121.000	.078	.025
20	-52.94	115.000	.078	.025
21	-52.57	109.000	.078	.040
22	-52.01	103.000	.078	.050
23	-50.79	97.000	.078	.050
24	-48.00	92.000	.100	.040
25	-42.12	88.687	.100	.040
26	-35.70	87.555	.100	.040
27	-29.28	87.125	.100	.040
28	-22.86	87.010	.100	.025
29	-16.44	87.000	.100	.025
30	-10.96	87.000	.100	.025
31	5.48	87.000	.100	.025
32	.00	87.000	.100	.025
33	5.48	87.000	.100	.025
34	10.96	87.000	.100	.025
35	16.44	87.000	.100	.025
36	22.86	87.010	.100	.040
37	29.28	87.125	.100	.040
38	35.70	87.555	.100	.040
39	42.12	88.687	.100	.040
40	48.00	92.000	.100	.050

TABLE 3 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.79	97.000	.078	.040
42	52.01	103.000	.078	.025
43	52.57	109.000	.078	.025
44	52.94	115.000	.078	.025
45	52.96	121.000	.078	.025
46	53.00	127.000	.078	.032
47	52.98	133.000	.078	.032
48	52.91	139.000	.078	.032
49	52.81	145.000	.063	.032
50	52.64	151.000	.063	.032
51	52.37	157.000	.063	.032
52	51.98	163.000	.078	.032
53	51.38	169.000	.063	.025
54	50.42	174.500	.078	.025
55	47.56	180.000	.063	.025
56	43.50	184.000	.078	.025
57	37.59	187.620	.078	.025
58	31.81	189.700	.078	.025
59	26.00	190.760	.078	.025
60	20.00	191.000	.078	.025
61	13.25	191.000	.078	.025
62	6.75	191.000	.078	.025

TABLE 3 (continued)

F.S. = 482-502.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	-.00	191.000	.063	.025
2	-6.75	191.000	.078	.025
3	-13.25	191.000	.078	.025
4	-20.00	191.000	.078	.025
5	-26.00	190.760	.078	.025
6	-31.81	189.700	.078	.025
7	-37.59	187.620	.078	.025
8	-43.50	184.000	.063	.025
9	-47.56	180.000	.078	.025
10	-50.42	174.500	.078	.025
11	-51.38	169.000	.078	.025
12	-51.98	163.000	.078	.032
13	-52.38	157.000	.063	.032
14	-52.64	151.000	.063	.032
15	-52.81	145.000	.063	.032
16	-52.91	139.000	.078	.016
17	-52.98	133.000	.078	.032
18	-53.00	127.000	.078	.025
19	-52.96	121.000	.078	.025
20	-52.94	115.000	.078	.025
21	-52.57	109.000	.078	.025
22	-52.01	103.000	.078	.020
23	-50.79	97.000	.270	.050
24	-48.00	92.000	.100	.040
25	-42.12	88.687	.100	.040
26	-35.70	87.555	.100	.040
27	-29.28	87.125	.100	.040
28	-22.86	87.010	.100	.025
29	-16.44	87.000	.100	.025
30	-10.96	87.000	.100	.025
31	5.48	87.000	.100	.025
32	.00	87.000	.100	.025
33	5.48	87.000	.100	.025
34	10.96	87.000	.100	.025
35	16.44	87.000	.100	.025
36	22.86	87.010	.100	.040
37	29.28	87.125	.100	.040
38	35.70	87.555	.100	.040
39	42.12	88.687	.100	.040
40	48.00	92.000	.100	.050

TABLE 3 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.79	97.000	.270	.020
42	52.01	103.000	.078	.025
43	52.57	109.000	.078	.025
44	52.94	115.000	.078	.025
45	52.96	121.000	.078	.025
46	53.00	127.000	.078	.032
47	52.98	133.000	.078	.016
48	52.91	139.000	.078	.032
49	52.81	145.000	.063	.032
50	52.64	151.000	.063	.032
51	52.37	157.000	.063	.032
52	51.98	163.000	.078	.025
53	51.38	169.000	.063	.025
54	50.42	174.500	.078	.025
55	47.56	180.000	.063	.025
56	43.50	184.000	.078	.025
57	37.59	187.620	.078	.025
58	31.81	189.700	.078	.025
59	26.00	190.760	.078	.025
60	20.00	191.000	.078	.025
61	13.25	191.000	.078	.025
62	6.75	191.000	.078	.025

TABLE 3 (continued)

F.S. = 502-522.

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
1	-.00	191.000	.063	.025
2	-6.75	191.000	.078	.025
3	-13.25	191.000	.078	.025
4	-20.00	191.000	.078	.025
5	-26.00	190.760	.078	.025
6	-31.81	189.700	.078	.025
7	-37.59	187.620	.078	.025
8	-43.50	184.000	.063	.025
9	-47.36	180.000	.078	.025
10	-50.42	174.500	.078	.025
11	-51.38	169.000	.078	.025
12	-51.98	163.000	.078	.032
13	-52.38	157.000	.063	.032
14	-52.64	151.000	.063	.032
15	-52.81	145.000	.063	.032
16	-52.91	139.000	.078	.032
17	-52.98	133.000	.078	.032
18	-53.00	127.000	.078	.025
19	-52.96	121.000	.078	.025
20	-52.94	115.000	.078	.025
21	-52.57	109.000	.078	.025
22	-52.01	103.000	.078	.040
23	-50.79	97.000	.270	.050
24	-48.00	92.000	.157	.040
25	-42.12	88.687	.157	.040
26	-35.70	87.555	.157	.040
27	-29.28	87.125	.157	.040
28	-22.86	87.010	.157	.025
29	-16.44	87.000	.157	.025
30	-10.96	87.000	.157	.025
31	5.48	87.000	.157	.025
32	.00	87.000	.157	.025
33	5.48	87.000	.157	.025
34	10.96	87.000	.157	.025
35	16.44	87.000	.157	.025
36	22.86	87.010	.157	.040
37	29.28	87.125	.157	.040
38	35.70	87.555	.157	.040
39	42.12	88.687	.157	.040
40	48.00	92.000	.157	.050

TABLE 3 (continued)

STRINGER NO.	B.L.	W.L.	AREA	PANEL THICKNESS
41	50.79	97.000	.270	.040
42	52.01	103.000	.078	.025
43	52.57	109.000	.078	.025
44	52.94	115.000	.078	.025
45	52.96	121.000	.078	.025
46	53.00	127.000	.078	.032
47	52.98	133.000	.078	.032
48	52.91	139.000	.078	.032
49	52.81	145.000	.063	.032
50	52.64	151.000	.063	.032
51	52.37	157.000	.063	.032
52	51.98	163.000	.078	.025
53	51.38	169.000	.063	.025
54	50.42	174.500	.078	.025
55	47.56	180.000	.063	.025
56	43.50	184.000	.078	.025
57	37.59	187.620	.078	.025
58	31.81	189.700	.078	.025
59	26.00	190.760	.078	.025
60	20.00	191.000	.078	.025
61	13.25	191.000	.078	.025
62	6.75	191.000	.078	.025

TABLE 4
STRINGER AND PANEL IDENTIFICATION
RAMP F.S. 522-612

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
522. AFT	1	6.8	190.9	.137	.032
	2	6.8	190.9	.137	.032
	3	13.2	190.9	.078	.032
	4	20.0	190.9	.144	.025
	5	26.0	190.7	.078	.025
	6	31.8	189.6	.078	.025
	7	37.6	187.5	.078	.025
	8	43.5	183.9	.078	.025
	9	47.6	179.9	.078	.025
	10	50.4	174.7	.078	.025
	11	51.4	169.0	.153	.025
	12	52.0	163.0	.063	.025
	13	52.4	157.0	.063	.025
	14	52.6	151.0	.063	.025
	15	52.8	145.0	.063	.025
	16	52.9	139.0	.2422	.025
	17	53.0	133.0	.063	.025
	18	53.0	127.0	.063	.025
	19	53.0	121.0	.063	.025
	20	52.9	115.0	.063	.025
	21	52.5	109.0	.063	.025
	22	51.9	103.0	.063	.025
	23	50.6	97.5	1.1888	0.0
	24	-50.6	97.5	1.0754	0.025
	25	-51.9	103.0	.063	.025
	26	-52.5	109.0	.063	.025
	27	-52.9	115.0	.063	.025
	28	-53.0	121.0	.063	.025
	29	-53.0	127.0	.063	.025
	30	-53.0	133.0	.063	.025
	31	-52.9	139.0	.2422	.025
	32	-52.8	145.0	.063	.025
	33	-52.6	151.0	.063	.025
	34	-52.4	157.0	.063	.025
	35	-52.0	163.0	.063	.025
	36	-51.4	169.0	.153	.025
	37	-50.4	174.7	.078	.025
	38	-47.6	179.9	.078	.025
	39	-43.5	183.9	.078	.025
	40	-37.6	187.5	.078	.025
	41	-31.8	189.6	.078	.025
	42	-26.0	190.7	.078	.032

TABLE 4 (continued)

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
522. (cont.) AFT	43	-20.0	190.9	.144	.032
	44	-13.2	190.9	.078	.032
	45	-6.8	190.9	.137	.032
	46	-6.8	190.9	.137	.025

TABLE 5
STRINGER AND PANEL IDENTIFICATION
RAMP F.S. 522-612

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	STRINGER LOCATION W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
544.5 AFT	1	6.8	189.6	.135	.040
	2	6.8	190.9	.135	.032
	3	13.2	190.9	.078	.032
	4	20.0	190.9	.144	.025
	5	25.4	190.7	.078	.025
	6	30.55	189.6	.078	.025
	7	36.15	187.5	.078	.025
	8	42.15	183.9	.078	.025
	9	46.25	179.9	.078	.025
	10	49.5	174.7	.078	.025
	11	50.9	169.0	.120	.025
	12	51.6	163.0	.063	.025
	13	52.0	157.0	.063	.025
	14	52.35	151.0	.063	.025
	15	52.4	145.0	.063	.025
	16	52.4	139.0	.2422	.025
	17	52.65	133.0	.063	.025
	18	52.7	127.0	.063	.025
	19	52.6	121.0	.063	.025
	20	52.35	115.0	.063	.025
	21	51.85	190.0	.063	.025
	22	ENDS IN BAY 522-544			
	23	50.6	107.75	1.2328	0.0
	24	-50.6	107.75	1.1106	.025
	25	ENDS IN BAY 522-544			
	26	-51.85	109.0	.063	.025
	27	-52.35	115.0	.063	.025
	28	-52.6	121.0	.063	.025
	29	-52.7	127.0	.063	.025
	30	-52.65	133.0	.063	.025
	31	-52.4	139.0	.2422	.025
	32	-52.4	145.0	.063	.025
	33	-52.35	151.0	.063	.025
	34	-52.0	157.0	.063	.025
	35	-51.6	163.0	.063	.025
	36	-50.9	169.0	.120	.025
	37	-49.5	174.7	.078	.025
	38	-46.25	179.9	.078	.025
	39	-42.15	183.9	.078	.025
	40	-36.15	187.5	.078	.025
	41	-30.55	189.6	.078	.025
	42	-25.4	190.7	.078	.025

TABLE 5 (continued)

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
544.5 (cont.)	43	-20.0	190.9	.144	.032
AFT	44	-13.2	190.9	.078	.032
	45	-6.8	190.9	.135	.040
	46	-6.8	189.6	.135	.025

TABLE 6
STRINGER AND PANEL IDENTIFICATION
RAMP F.S. 522-612

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
567.0 AFT	1	6.8	188.5	.137	.04
	2	6.8	190.9	.137	.032
	3	13.2	190.9	.078	.032
	4	20.0	190.9	.144	.025
	5	24.75	190.7	.078	.025
	6	29.5	189.6	.078	.025
	7	35.0	187.5	.078	.025
	8	41.2	183.9	.078	.025
	9	45.2	179.9	.078	.025
	10	49.2	174.7	.078	.025
	11	50.75	169.0	.120	.025
	12	51.6	163.0	.063	.025
	13	52.1	157.0	.063	.025
	14	52.3	151.0	.063	.025
	15	52.5	145.0	.063	.025
	16	52.5	139.0	.2422	.025
	17	52.6	133.0	.063	.025
	18	52.5	127.0	.063	.025
	19	52.2	121.0	.063	.025
	20	ENDS IN BAY 544-567			
	23	52.0	116.75	1.2408	0.0
	24	-52.0	116.75	1.1166	0.025
	27	ENDS IN BAY 544-567			
	28	-52.2	121.0	.063	.025
	29	-52.5	127.0	.063	.025
	30	-52.6	133.0	.063	.025
	31	-52.5	139.0	.2422	.025
	32	-52.5	145.0	.063	.025
	33	-52.3	151.0	.063	.025
	34	-52.1	157.0	.063	.025
	35	-51.6	163.0	.063	.025
	36	-50.75	169.0	.1200	.025
	37	-49.2	174.7	.078	.025
	38	-45.2	179.9	.078	.025
	39	-41.2	183.9	.078	.025
	40	-35.0	187.5	.078	.025
	41	-29.5	189.6	.078	.025
	42	-24.7	190.7	.078	.025
	43	-20.0	190.9	.144	.032
	44	-13.2	190.9	.078	.032
	45	-6.8	190.9	.137	.040
	46	-6.8	188.5	.137	.025

TABLE 7
STRINGER AND PANEL IDENTIFICATION
RAMP F.S. 522-612

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN2)	PANEL THICKNESS (IN)
589.9 AFT	1	6.8	187.65	.1400	.040
	2	6.8	190.9	.1400	.032
	3	13.2	190.9	.0780	.032
	4	20.0	190.9	.1440	.025
	5	ENDS AT F.S. 589.5			
	6	28.2	189.6	078	.025
	7	33.5	187.5	.078	.025
	8	39.75	183.9	.078	.025
	9	44.20	179.9	.078	.025
	10	48.25	174.7	.078	.025
	11	50.3	169.0	.1200	.025
	12	51.3	163.0	.063	.025
	13	51.9	157.0	.063	.025
	14	52.15	151.0	.063	.025
	15	52.3	145.0	.063	.025
	16	52.3	139.0	.1940	.025
	17	52.2	133.0	.063	.025
	18	ENDS AT F.S. 589.5			
	19	ENDS IN BAY 567-589.5			
	23	51.85	126.4	1.2248	0.0
	24	-51.85	126.4	1.1042	.025
	28	ENDS IN BAY 567-589.5			
	29	ENDS AT F.S. 589.5			
	30	052.2	133.0	.063	.025
	31	-52.3	139.0	.1942	.025
	32	-52.3	145.0	.063	.025
	33	-52.15	151.0	.063	.025
	34	-51.90	157.0	.063	.025
	35	-51.3	163.0	.063	.025
	36	-50.3	169.0	.1200	.025
	37	-48.25	174.7	.078	.025
	38	-44.2	179.9	.078	.025
	39	-39.75	183.9	.078	.025
	40	-33.5	187.5	.078	.025
	41	-28.2	189.6	.078	.025
	42	ENDS AT F.S. 589.5			
	43	-20.0	190.9	.1440	.032
	44	-13.2	190.9	.078	.032
	45	-6.8	190.9	.1370	.040
	46	-6.8	187.65	.1370	.025

TABLE 8
STRINGER AND PANEL IDENTIFICATION
RAMP F.S. 522-612

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
					.040
612.	1	6.8	188.0	.1170	.032
FORWARD	2	6.8	192.3	.1170	.032
	3	13.2	192.3	.078	.025
	4	20.0	192.1	.1440	.025
	6	27.1	191.1	.078	.025
	7	32.3	189.6	.078	.025
	8	38.5	186.4	.078	.025
	9	42.8	182.0	.078	.025
	10	47.1	176.9	.078	.025
	11	49.5	170.0	.1200	.025
	12	50.6	163.0	.063	.025
	13	51.1	156.9	.063	.025
	14	51.3	151.0	.063	.025
	15	51.3	145.0	.063	.025
	16	ENDS AT F.S. 612			
	17	ENDS IN BAY 589-612			
	23	51.0	135.9	1.1768	0.
	24	-51.0	135.9	1.0658	.025
	30	ENDS IN BAY 589-61			
	31	ENDS AT F.S. 612			
	32	-51.3	145.0	.063	.025
	33	-51.3	151.0	.063	.025
	34	-51.1	156.9	.063	.025
	35	-50.6	163.0	.025	
	36	-49.5	170.0	.1200	.025
	37	-47.1	176.9	.078	.025
	38	-42.8	182.0	.078	.025
	39	-38.5	186.4	.078	.025
	40	-32.3	189.6	.078	.025
	41	-27.1	191.1	.078	.025
	43	-20.0	192.1	.144	.032
	44	-13.2	192.3	.078	.032
	45	-6.8	192.3	.117	.040
	46	-6.8	188.0	.117	.025

TABLE 9
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	STRINGER LOCATION W.L.	STRINGER AREA (IN2)	PANEL THICKNESS (IN)
612. AFT	1	-6.8	188.0	.082	.040
	2	-6.8	192.3	.082	.032
	3	-13.2	192.3	.072	.040
	4	-20.0	192.1	.214	.040
	5	-27.1	191.1	.078	.040
	6	-32.3	189.6	.072	.040
	7	-38.5	186.4	.072	.040
	8	-42.5	182.8	.070	.040
	9	-44.8	179.85	0.0	.040
	10	-47.1	176.9	.072	.040
	11	-48.3	173.45	0.0	.040
	12	-49.5	170.0	0.50	.063
	13	-44.0	170.0	.216	.032
	14	-38.5	170.0	.0599	.032
	15	-29.0	170.0	.0599	.032
	16	-17.5	170.0	.0599	.032
	17	-6.84	170.0	.1445	.056
	18	0.	170.0	.0599	.056
	19	6.84	170.0	.1445	.032
	20	17.5	170.0	.0599	.032
	21	29.0	170.0	.0599	.032
	22	38.5	170.0	.0599	.032
	23	44.0	170.0	.2160	.063
	24	49.5	170.0	.500	.040
	25	47.1	176.9	.072	.040
	26	42.5	182.8	.072	.040
	27	38.5	186.4	.072	.040
	28	32.3	189.6	.072	.040
	29	27.1	191.1	.078	.040
	30	20.0	192.1	.214	.032
	31	13.2	192.3	0.0	.032
	32	10.0	192.3	.072	.032
	33	6.8	192.3	.082	.040
	34	6.8	188.0	.082	.025

TABLE 10
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	STRINGER LOCATION W.L.	STRINGER AREA (IN2)	PANEL THICKNESS (IN)
650.5	1	-6.75	186.8	.082	.040
AFT	2	-6.75	192.7	.082	.032
	3	-13.2	192.7	.072	.032
	4	-20.0	192.2	.214	.032
	5	-24.9	191.4	.072	.032
	6	-29.8	190.0	.072	.032
	7	-36.1	187.0	.072	.032
	8	-40.2	183.5	.072	.032
	9	-42.15	180.5	0.074	.032
	10	-44.1	177.5	.072	.032
	11	-45.1	173.75	0.074	.032
	12	-46.1	170.0	1.48	.063
	13	-38.7	170.0	.338	.032
	14	-32.5	170.0	.0599	032
	15	-24.0	170.0	.0599	.032
	16	-15.8	170.0	.0599	.032
	17	-6.84	170.0	.1462	.032
	18	0.0	170.0	.0599	.032
	19	6.84	170.0	.1462	.032
	20	15.80	170.0	.0599	.032
	21	24.0	170.0	.0599	.032
	22	32.5	170.0	.0599	.032
	23	38.7	170.0	.338	.063
	24	46.1	170.0	1.48	.032
	25	44.1	177.5	.072	.032
	26	40.2	183.5	.072	.032
	27	36.1	187.0	.072	.032
	28	29.8	190.0	.072	.032
	29	24.9	191.4	.072	.032
	30	20.0	192.2	.214	.032
	31	16.6	192.45	0.0	.032
	32	13.2	192.7	.072	.032
	33	6.75	192.8	.082	.040
	34	6.75	186.8	.082	.032

TABLE 11
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN2)	PANEL THICKNESS (IN)
689.5	1	-6.75	185.6	.082	.040
AFT	2	-6.75	193.2	.082	.032
	3	-13.25	192.9	.072	.032
	4	-20.0	192.1	.214	.032
	5	- 4.9	191.4	0.0	.032
	6	-27.1	190.2	.072	.032
	7	-33.0	187.0	.072	.032
	8	-36.7	183.5	.076	.032
	9	-38.0	179.5	.074	.032
	10	-38.9	177.4	.072	.032
	11	-39.0	173.7	.074	.032
	12	-38.2	170.0	.743	.063
	13	-33.1	170.0	.332	.032
	14	-32.5	170.0	.0599	.032
	15	-24.0	170.0	.0599	.032
	16	-15.8	170.0	.0599	.032
	17	-6.84	170.0	.1462	.032
	18	0.0	170.0	0.0	.032
	19	6.84	170.0	.1462	.032
	20	15.8	170.0	.0599	.032
	21	24.0	170.0	.0599	.032
	22	32.5	170.0	.0599	.032
	23	33.1	170.0	.332	.063
	24	38.2	170.0	.743	.032
	25	38.9	177.4	.072	.032
	26	36.7	183.5	.076	.032
	27	33.0	187.0	.072	.032
	28	27.1	190.2	.072	.032
	29	24.9	191.5	0.0	.032
	30	20.0	192.1	.214	.032
	31	18.2	192.8	.300	.032
	32	13.25	192.9	.072	.032
	33	6.75	193.2	.082	.040
	34	6.75	185.6	.082	.032

TABLE 12
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
706.	1	-6.8	185.1	.082	.040
AFT	2	-6.8	193.5	.082	.032
	3	-13.3	193.1	.072	.032
	4	-19.3	192.2	.214	.032
	5	-22.6	191.15	0.0	.032
	6	-25.9	190.1	.072	.032
	7	-31.5	186.4	.072	.032
	8	-34.4	182.5	.101	.032
	9	-34.85	179.85	0.0	.032
	10	-35.3	177.2	.106	.032
	11	-34.6	173.6	0.0	.032
	12	-34.0	170.0	.825	.063
	13	-30.7	170.0	.518	.032
	14	-23.1	170.0	.095	.049
	15	-16.5	170.0	.0599	.049
	16	-10.0	170.0	0.0	.049
	17	-6.84	170.9	.1462	.057
	18	0.0	170.0	0.0	.057
	19	6.84	170.0	.1462	.032
	20	10.0	170.0	0.0	.032
	21	16.5	170.0	.0599	.032
	22	23.1	170.0	.0599	.032
	23	30.7	170.0	.334	.063
	24	34.0	170.0	.813	.032
	25	35.3	177.2	.072	.032
	26	34.4	182.5	.073	.032
	27	31.5	186.4	.072	.032
	28	25.9	190.1	.072	.032
	29	22.6	191.5	0.0	.032
	30	19.3	192.2	.214	.032
	31	17.6	192.65	.300	.032
	32	13.3	193.1	.072	.032
	33	6.8	193.5	.082	.040
	34	6.8	185.1	.082	.032

TABLE 13
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	STRINGER LOCATION W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
736.8 AFT	1	-6.8	184.9	.082	.050
	2	-6.8	194.6	.082	.050
	3	-13.3	193.9	.072	.050
	4	-18.7	192.6	.1800	.050
	5	-24.9	188.6	0.0	.050
	6	-25.0	188.5	0.0	.070
	7	-25.1	188.4	1.562	.050
	8	-28.0	180.2	.8680	.0600
	9	-28.1	180.1	0.0	.060
	10	-27.8	176.2	.9330	.090
	11	-25.8	170.1	0.0	.090
	12	-25.7	170.0	.527	.063
	13	-22.3	170.0	.5180	.063
	14	-17.8	170.0	.0599	.063
	15	-12.0	170.0	0.0	.063
	16	-8.0	170.0	0.0	.063
	17	-6.84	170.0	.1462	.063
	18	0.0	170.0	.1175	.063
	19	6.84	170.0	.1462	.063
	20	8.0	170.0	0.0	.063
	21	12.0	170.0	0.0	.063
	22	17.8	170.0	.0599	0.0
	23	22.3	170.0	.2540	0.0
	24	25.7	170.0	.5270	.060
	25	27.8	176.4	.072	.050
	26	27.4	184.3	0.0	.050
	27	27.5	184.4	.1440	.050
	28	23.8	190.0	.0720	.050
	29	17.7	192.9	0.0	.050
	30	17.6	193.0	.4284	.060
	31	13.4	193.8	.4536	.060
	32	13.3	193.9	.0720	.050
	33	6.8	194.6	.0820	.050
	34	6.8	184.9	.0820	.050

TABLE 14
STRINGER AND PANEL IDENTIFICATION
TAIL CONE F.S. 612-746

FUSELAGE STATION	STRINGER & PANEL NUMBER	STRINGER LOCATION B.L.	STRINGER LOCATION W.L.	STRINGER AREA (IN^2)	PANEL THICKNESS (IN)
746.88	1	-6.8	184.6	.090	.050
FORWARD	2	-6.8	194.8	.082	.050
	3	-13.3	193.9	.072	.050
	4	-18.6	192.1	.1560	.050
	5	-19.99	191.1	0.0	.050
	6	-21.32	190.1	0.0	.070
	7	-22.6	189.1	1.562	.050
	8	-25.0	183.0	3.6480	.060
	9	-25.55	181.0	0.0	.060
	10	-26.10	179.0	3.6480	.090
	11	-24.35	174.5	0.0	.090
	12	-22.6	170.0	.6450	.063
	13	-19.6	170.0	.5180	.063
	14	-15.2	170.0	.1512	.063
	15	-12.0	170.0	0.0	.063
	16	-8.0	170.0	0.0	.063
	17	-6.89	170.0	.4130	.063
	18	0.0	170.0	.1175	.063
	19	6.84	170.0	.4130	.063
	20	8.0	170.0	0.0	.063
	21	12.0	170.0	0.0	.063
	22	17.5	170.0	4.42	0.0
	23	19.6	170.0	.572	0.0
	24	2[illegible].6	170.0	.7950	.060
	25	24.7	179.0	.072	.050
	26	24.[illegible]	180.8	0.0	.050
	27	25.1	182.6	.1440	.050
	28	22.6	189.1	.072	.050
	29	20.5	190.9	0.0	.050
	30	17.5	192.7	1.1190	.060
	31	15.4	193.3	1.3	.060
	32	13.3	193.9	.072	.050
	33	6.9	194.8	.090	.050
	34	6.9	184.6	.082	.050

TABLE 15

FRAME PROPERTIES, FS 262-442, 62 STRINGER STRUCTURE

Frame Element No.	Coordinates of First End of Element Y (B.L)	Z (W.L)	Frame F.S. 262 I	F.S. 262 A	F.S. 282 I	F.S. 282 A	F.S. 302 I	F.S. 302 A	F.S. 322 I	F.S. 322 A
1	0.0	191.0	12.63	.658	7.0	.54	21.46	.92	352.	13.16
2	-7.0	191.0	2.31	.524	1.74	.38	21.46	.91	370.	14.44
3	-13.0	191.0	2.31	.524	1.74	.38	21.46	.89	319.9	11.97
4	-20.0	191.0	13.18	.877	3.90	.43	23.04	1.60	243.2	8.98
5	-26.0	190.76	21.64	[illegible]	8.35	.55	21.15	1.58	193.8	7.93
6	-31.81	189.7	20.17	.894	8.8	.51	18.27	1.76	149.6	7.29
7	-37.59	187.62	9.585	1.119	5.05	.51	[illegible]	1.81	87.6	6.27
8	-43.3	184.0	6.55	1.01	2.02	.43	10.35	2.94	40.5	5.86
9	-47.56	180.0	2.41	0.7	.85	.37	7.2	2.60	25.07	5.84
10	-50.42	174.5	.95	.421	.64	.35	7.57	3.46	17.29	6.20
11	-51.38	169.0	.694	.366	.63	.36	6.20	2.9	16.41	6.47
12	-51.98	163.0	.677	.368	.63	.36	2.52	1.49	14.32	4.55
13	-52.39	157.0	.677	.368	.63	.36	2.39	1.20	10.30	2.72
14	-52.64	151.0	1.315	.75	.69	.39	1.55	1.05	8.40	2.21
15	-52.82	145.0	.959	.47	.77	.44	2.11	1.12	6.39	1.84
16	-52.9	139.0	.935	.462	.80	.45	2.18	1.17	5.78	1.57
17	-52.98	133.0	.896	.46	.81	.45	1.97	1.09	5.21	1.43
18	-53.0	127.0	.85	.46	.82	.46	1.83	1.04	5.85	1.58
19	-52.97	121.0	.839	.46	.83	.464	1.51	.88	5.41	1.61
20	-52.84	115.0	.995	.576	1.51	.71	2.1	.91	4.91	1.57
21	-52.57	109.0	1.70	.742	2.16	.87	7.5	1.78	7.10	1.69
22	-52.02	103.0	2.67	.897	3.55	1.53	12.6	2.6	12.45	2.33
23	-50.84	97.0	3.09	1.045	3.77	1.21	7.2	2.7	9.01	2.11
24	-48.0	92.0	4.8	1.26	4.96	1.22	7.8	2.05	14.15	2.12
25	-42.12	88.68	8.6	1.39	8.47	1.38	8.95	1.45	18.93	1.96
26	-35.7	87.55	9.23	1.13	9.88	1.08	10.4	1.35	17.86	1.53
27	-29.28	87.13	9.7	1.11	10.03	1.13	13.35	1.65	19.07	1.48
28	-22.86	87.01	10.0	1.09	10.39	1.09	11.40	1.18	22.57	1.69
29	-16.44	87.0	10.32	1.07	10.02	1.00	11.53	1.18	28.97	2.09
30	-10.96	87.0	10.65	1.05	9.96	.98	12.6	1.25	32.63	2.30
31	-5.48	87.0	10.82	1.045	9.96	.98	13.85	1.38	51.22	4.54
32	0.0	87.0	10.82	1.05	9.96	.98	12.9	1.28	51.22	4.54
33	5.48	87.0	10.65	1.05	9.96	.98	11.7	1.10	36.11	2.49
34	10.96	87.0	10.32	1.07	10.02	1.00	12.95	1.50	33.53	2.32
35	16.44	87.0	10.0	1.09	10.39	1.09	15.10	2.05	28.83	2.09
36	22.86	87.01	9.7	1.11	10.03	1.13	13.35	1.65	22.81	1.75
37	29.28	87.22	9.23	1.13	9.88	1.08	1.04	1.35	17.86	1.53
38	35.40	87.55	8.6	1.39	8.47	1.38	8.95	1.45	18.95	1.96
39	42.12	88.69	4.8	1.26	4.96	1.22	7.8	2.05	14.15	2.12
40	48.7	92.0	3.09	1.045	3.77	1.21	7.2	2.7	9.01	2.11

Frame Element No.	F.S. 342 I	F.S. 342 A	F.S. 362 I	F.S. 362 A	F.S. 382 I	F.S. 382 A	F.S. 402 I	F.S. 402 A	F.S. 422 I	F.S. 422 A	F.S. 442 I	F.S. 442 A
1	0.0	0.0	352.8	11.81	22.57	1.01	9.68	.44	7.179	.238	33.82	1.11
2	0.0	0.0	477.9	16.34	23.2	1.02	9.26	.43	8.12	.396	33.82	1.11
3	0.0	0.0	350.1	12.39	24.0	1.03	8.84	.42	6.48	.214	33.82	1.11
4	91.0	2.81	256.1	9.87	32.6	1.42	9.82	.53	6.48	.214	38.51	1.38
5	44.9	1.71	222.8	8.92	34.3	1.58	10.09	.62	6.59	.295	51.5	2.15
6	14.0	.91	163.5	8.13	34.1	1.78	7.64	.51	6.76	.472	51.	2.56
7	7.4	.75	95.1	6.82	45.0	1.93	4.74	.48	4.81	.509	30.	2.38
8	3.49	.77	46.5	5.98	16.2	1.88	2.40	.51	1.93	.426	15.	2.24
9	2.10	.80	16.0	4.5	7.21	1.68	1.09	.46	1.09	.465	14.5	2.2
10	.54	.76	12.4	3.98	5.60	1.51	.93	.46	1.085	.53	22.45	2.54
11	1.22	.64	13.5	4.45	5.30	1.46	1.00	.48	1.02	.496	17.90	2.02
12	1.22	.64	14.28	4.70	5.51	1.51	1.02	.49	1.20	.519	26.	2.6
13	1.25	.64	[illegible]	3.02	5.81	1.59	1.04	.50	1.398	.574	31.6	3.12
14	1.31	.65	5.70	1.85	6.3	1.74	1.02	.49	1.398	.574	35.2	3.5
15	1.31	.66	5.60	1.68	7.0	1.95	1.00	.48	1.215	.52	43.7	3.98
16	1.40	.70	5.15	1.51	84.6	3.0	1.00	.48	1.032	.487	49.0	4.4
17	1.60	.78	4.70	1.32	79.0	4.6	1.03	.49	1.10	.507	54.0	4.96
18	1.82	.90	4.37	1.20	62.5	4.2	1.07	.50	1.10	.507	56.5	5.3
19	2.02	.99	4.23	1.18	48.2	3.4	1.05	.49	1.10	.507	[illegible]	6.57
20	2.71	1.06	5.22	1.21	47.7	2.85	1.41	.55	1.46	.55	169.8	7.17
21	3.78	1.25	7.73	1.67	48.5	2.5	2.50	.72	2.5	.72	171.6	6.09
22	5.40	1.48	11.07	2.39	50.4	2.69	3.40	.96	3.4	.96	156.3	5.58
23	7.07	2.14	12.59	2.68	31.0	2.66	3.35	1.20	3.85	1.20	58.0	4.77
24	10.42	1.84	10.65	2.22	18.0	2.45	4.96	1.17	4.96	1.17	31.5	4.95
25	12.91	1.55	8.89	1.47	24.8	2.82	7.47	1.05	7.47	1.05	47.11	4.88
26	13.56	1.27	9.71	1.17	16.3	1.86	9.65	1.11	9.65	1.11	38.6	3.25
27	20.27	1.58	10.90	1.09	15.1	1.54	9.94	1.01	9.94	1.02	26.8	2.16
28	28.71	2.08	11.39	1.11	15.6	1.52	9.86	.92	9.86	.92	22.87	1.59
29	34.06	2.45	11.60	1.13	15.4	1.48	10.00	.91	10.00	.92	20.31	1.56
30	37.05	2.58	11.70	1.15	15.1	1.40	9.90	.89	9.90	.89	18.56	1.49
31	54.48	4.47	11.80	1.17	14.7	1.30	9.90	.89	9.90	.89	19.37	1.45
32	54.4[illegible]	4.47	11.80	1.17	14.7	1.3	9.90	.89	9.90	.89	19.37	1.49
33	37.56	4.36	11.70	1.15	15.1	1.40	9.90	.89	9.90	.89	18.56	1.49
34	35.44	2.55	11.6	1.13	15.4	1.48	10.00	.91	10.00	.92	20.31	1.56
35	29.04	2.15	11.39	1.11	15.6	1.52	9.86	.92	9.86	.92	22.87	1.59
36	21.17	1.57	10.90	1.09	15.1	1.54	9.94	1.01	9.94	1.01	26.8	2.16
37	13.56	1.27	9.71	1.17	16.3	1.86	9.65	1.11	9.65	1.11	38.6	3.25
38	12.91	1.55	8.89	1.47	24.8	2.82	7.47	1.05	7.47	1.05	47.11	4.88
39	10.42	1.84	10.65	2.22	18.0	2.45	4.96	1.17	4.96	1.17	31.5	4.95
40	7.07	2.14	12.59	2.68	31.0	2.66	3.85	1.20	3.85	1.2	58.	4.77

TABLE 15 (continued)

*Same Element No.	Coordinates of First End of Element Y (B.L)	Z (W.L)	Frame F.S. 262 I	F.S. 262 A	F.S. 282 I	F.S. 282 A	F.S. 302 I	F.S. 302 A	F.S. 322 I	F.S. 322 A
41	50.76	97.0	2.67	.897	3.65	1.53	11.1	2.7	12.45	2.33
42	52.02	103.0	1.70	.742	2.16	.87	7.5	1.83	7.10	1.69
43	52.575	109.0	.995	.576	1.51	.71	2.1	.91	4.91	1.57
44	52.84	115.0	.829	.464	.83	.464	1.51	.88	5.41	1.61
45	52.965	121.0	.85	.46	.82	.46	1.83	1.04	5.85	1.58
46	53.0	127.0	.896	.46	.81	.454	1.97	1.09	5.21	1.43
47	52.94	133.0	.935	.462	.80	.45	2.18	1.17	5.78	1.57
48	52.915	139.0	.959	.47	.77	.44	2.11	1.12	6.89	1.84
49	52.815	145.0	1.315	.75	.69	.39	1.96	1.05	8.40	2.21
50	52.64	151.0	.677	.368	.63	.36	2.35	1.20	10.30	2.72
51	52.378	157.0	.677	.368	.63	.36	2.52	1.49	14.32	4.55
52	51.98	163.0	.654	.366	.53	.36	6.20	2.8	16.41	6.47
53	52.38	169.0	.85	.421	.64	.35	7.57	3.46	17.29	6.20
54	50.42	174.7	2.41	.7	.35	.37	7.2	2.60	25.07	5.84
55	47.46	180.0	6.55	1.01	2.02	.43	10.35	2.94	40.5	5.86
56	43.50	184.0	9.59	1.12	5.05	.51	13.1	1.81	87.6	6.23
57	37.59	187.62	10.22	.81	8.8	.57	18.27	1.76	149.8	7.25
58	31.81	189.7	11.03	.60	10.9	.61	21.15	1.58	196.8	7.93
59	26.0	190.76	12.18	.62	11.75	.61	23.04	1.59	243.2	8.98
60	20.0	191.0	12.45	.62	12.17	.63	21.46	.86	318.9	11.97
61	13.0	191.0	12.55	.842	12.17	.66	21.46	.86	370.	14.44
62	7.0	191.0	12.55	.842	12.18	.69	21.46	.89	352.	13.16

*Same Element No.	F.S. 342 I	F.S. 342 A	F.S. 362 I	F.S. 362 A	F.S. 382 I	F.S. 382 A	F.S. 402 I	F.S. 402 A	F.S. 422 I	F.S. 422 A	F.S. 442 I	F.S. 442 A
41	5.40	1.48	11.07	2.39	50.4	2.69	3.40	.96	3.4	.96	156.3	5.58
42	3.78	1.25	7.52	1.74	48.5	2.5	2.50	.72	2.5	.72	171.6	6.09
43	2.71	1.06	4.63	1.30	47.7	2.85	1.41	.55	1.46	.55	189.8	7.17
44	2.02	.99	4.63	1.25	48.2	3.4	1.05	.49	1.10	.507	128.8	6.57
45	1.82	.90	3.47	1.16	62.5	4.2	1.07	.50	1.10	.507	56.5	5.3
46	1.60	.78	3.47	1.16	79.0	4.6	1.03	.49	1.10	.507	54.0	4.96
47	1.40	.70	3.70	1.29	24.6	3.0	1.0	.48	1.03	.487	49.0	4.4
48	1.31	.66	4.19	1.48	7.0	1.95	1.0	.48	1.22	.57	43.7	3.98
49	1.31	.65	4.65	1.64	6.3	1.74	1.02	.49	1.398	.574	35.2	3.5
50	1.25	.64	4.70	1.85	5.81	1.59	1.04	.50	1.398	.574	31.6	3.12
51	1.22	.64	7.85	2.75	5.51	1.51	1.02	.49	1.2	.529	26.	2.6
52	1.22	.64	12.7	4.05	5.30	1.46	1.00	.48	1.02	.496	17.9	2.02
53	1.54	.76	12.4	3.98	5.60	1.51	.93	.46	1.09	.53	22.45	2.54
54	2.10	.80	15.0	4.22	7.21	1.68	1.09	.46	1.09	.465	14.5	2.2
55	3.45	.77	32.5	4.85	16.2	1.88	2.40	.51	1.93	.476	15.	2.24
56	7.4	.75	77.3	5.83	45.0	1.93	4.74	.48	4.81	.509	30.	2.38
57	14.0	.91	138.0	7.10	34.1	1.78	7.64	.51	7.75	.505	51.0	2.56
58	44.9	1.71	186.2	8.44	34.3	1.58	10.09	.62	7.58	.328	51.5	2.15
59	91.0	2.81	261.2	9.51	32.6	1.42	9.82	.53	6.48	.214	38.51	1.39
60	0.0	0.0	332.3	11.75	24.	1.03	8.84	.42	6.48	.214	33.82	1.11
61	0.0	0.0	477.9	16.34	23.2	1.02	9.26	.43	8.12	.396	33.82	1.11
62	0.0	0.0	352.8	11.81	22.57	1.01	9.68	.44	7.18	.238	13.82	1.11

TABLE 16
LONGITUDINAL BEAM PROPERTIES, FS 262-442

END 1 F.S.	END 1 B.L.	END 1 W.L.	END 2 F.S.	END 2 B.L.	END 2 W.L.	Area (In^2)	I (In^4)
302.	-20.	191.	322.	-20.	191.	1.5128	21.6
322.	-20.	191.	342.	-20.	191.	3.1227	66.0
342.	-20.	191.	362.	-20.	191.	3.1227	66.0
362.	-20.	191.	382.	-20.	191.	1.6426	16.3
302.	+20.	191.	322.	+20.	191.	1.7708	25.6
322.	+20.	191.	342.	+20.	191.	3.1915	66.0
342.	+20.	191.	362.	+20.	191.	3.1915	66.0
362.	+20.	191.	382.	+20.	191.	1.4305	16.3
302.	-4.62	87.	322.	-4.62	87.	2.364	25.6
322.	-4.62	87.	342.	-4.62	87.	3.8123	37.0
342.	-4.62	87.	362.	-4.62	87.	1.979	14.8
322.	0.	87.	342.	0.	87.	0.*	74
342.	0.	87.	362.	0.	87.	1.1924	9.5

* No axial load continuity with members in bays forward and aft. Therefore, area assumed zero in model.

TABLE 17
CH-53, FRAN TEST VEHICLE
HORIZONTAL PANEL POINT DISTRIBUTION

PANEL POINT NO.	W(LB)	X(STA)	Z(WL)	I_{oxx} (LB-IN-SEC^2)	I_{oyy} (LB-IN-SEC^2)	I_{ozz} (LB-IN-SEC^2)
1	381.2	108.000	129.536	1158.	533.	625.
2	452.8	162.000	131.515	2440.	1216.	1228.
3	280.7	202.000	134.252	2155.	1090.	1097.
4	176.7	242.000	141.397	1377.	757.	626.
5	119.0	262.000	142.674	935.	549.	391.
6	102.9	282.000	139.606	778.	428.	355.
7	134.9	302.000	142.172	1048.	579.	473.
8	285.8	322.000	159.346	2287.	1453.	838.
9	148.6	342.000	129.428	1101.	731.	374.
10	248.4	362.000	153.855	1920.	1148.	777.
11	155.2	382.000	131.805	1258.	759.	504.
12	151.2	402.000	136.304	1213.	662.	557.
13	322.7	442.000	133.614	2531.	1351.	1189.
14	189.9	482.000	134.792	1466.	748.	741.
15	122.5	522.000	133.483	925.	533.	412.
16	233.8	567.000	151.874	1399.	679.	1143.
17	140.4	632.000	168.894	567.	155.	458.
18	144.5	689.000	174.481	263.	42.	274.
19	182.2	744.000	179.093	189.	45.	156.

TOTAL WEIGHT = 3973. LB

CENTROID (IN.) X = 357.95 Y = .00 Z = 143.03

TABLE 18
FRAN PHASE I
APPENDAGE MASS DATA SUMMARY CH-53A

PARAMETER		ADAPTER & LOWER PLATE	SHAKER	MAIN GEARBOX HOUSING
WEIGHT	(LBS)	541.	410.	601.
X_{cg}	F. STA.	336.3	336.0	339.8
Y_{cg}	F. B.L.	0.	0.	0.
Z_{cg}	F. W.L.	257.0	264.	207.8
I_{ox}	LB. IN.^{2}	56,954.	24,860.	134,408.
I_{oy}	LB. IN.^{2}	125,301.	7,946.	134,408.
I_{oz}	LB. IN.^{2}	182,831.	16,914.	180,025.

TABLE 19
SIX BAY ORIGINAL DEGREE OF FREEDOM MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	.9865	2	1.1718	3	.7264
4	.4572	5	.3079	6	.2598
7	.7052	8	.4914	9	.3170
10	.6050	11	.3633	12	.3739
13	.4715	14	.9865	15	1.1718
16	.7264	17	.4572	18	.3079
19	.2598	20	.7052	21	.4914
22	.3170	23	.6050	24	.3633
25	.3739	26	.4715	27	.9865
28	1.1718	29	.7264	30	.4572
31	.3079	32	.2598	33	.7052
34	.4914	35	.3170	36	.6050
37	.3633	38	.3739	39	.4715
40	1157.9999	41	2440.0000	42	2155.0000
43	1377.0000	44	935.0000	45	614.0000
46	2124.0000	47	1465.9999	48	925.0000
49	1399.0000	50	567.0000	51	263.0000
52	169.0000	53	533.0000	54	1215.9999
55	1090.0000	56	757.0000	57	549.0000
58	427.0000	59	1138.0000	60	748.0000
61	533.0000	62	679.0000	63	155.0000
64	42.0000	65	45.0000	66	625.0000
67	1228.0000	68	1096.9999	69	626.0000
70	391.0000	71	392.0000	72	993.0000
73	741.0000	74	412.0000	75	1343.0000
76	456.0000	77	274.0000	78	156.0000
79	.2663	80	.0336	81	.0277
82	.0336	83	.0858	84	.0283
85	.0259	86	.0283	87	.0358
88	.1709	89	.0302	90	.0277
91	.0302	92	.1709	93	.0934
94	.0439	95	.0403	96	.0439
97	.0934	98	.1535	99	.0344
100	.0316	101	.0344	102	.1535
103	.0253	104	.0208	105	.0253
106	.1100	107	.0377	108	.0346
109	.0377	110	.1100	111	.2613
112	.2663	113	.0475	114	.0475
115	.0443	116	.0416	117	.0412
118	.0412	119	.0416	120	.0443

TABLE 13 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
121	.1164	122	.0545	123	.0441
124	.0441	125	.0545	126	.1164
127	.0466	128	.0468	129	.0641
130	.0641	131	.0468	132	.0466
133	.1001	134	.0534	135	.0503
136	.0503	137	.0534	138	.1001
139	.0357	140	.0357	141	.0531
142	.0570	143	.0551	144	.0551
145	.0570	146	.0531	147	.2613
148	.2663	149	.0949	150	.0363
151	.0216	152	.0279	153	.0825
154	.0279	155	.0216	156	.0363
157	.1068	158	.0249	159	.0392
160	.0882	161	.0392	162	.0249
163	.1068	164	.0370	165	.0217
166	.0345	167	.1282	168	.0345
169	.0217	170	.0370	171	.0929
172	.0213	173	.0392	174	.1005
175	.0392	176	.0213	177	.0293
178	.0714	179	.0438	180	.0202
181	.0455	182	.1101	183	.0455
184	.0202	185	.0438	186	.2613
187	778.0000	188	428.0000	189	355.0000
190	804.0000	191	447.0000	192	361.0000
193	4.6308	194	4.6308	195	4.6308
196	2681.2600	197	2477.8800	198	1767.0500

TABLE 20

FUSELAGE BENDING AND TORSION PROPERTIES

FUSELAGE STATION	NEUTRAL AXIS B.L.(IN)	W.L.(IN)	Iy (IN^4)	Iz (IN^4)	J (IN^4)
162.	1.96	125.0	23480.	23818.	41568.
182.	6.259	125.3	29573.	22729.	44938.
202.	5.79	126.6	30430.	21141.	38069.
222.	2.31	130.8	28352.	22663.	31200.
242.	1.33	132.4	26041.	27443.	31900.
262.	.73	135.4	25343.	27000.	32600.
282.	.18	137.5	26783.	30546.	35995.
402.	-.24	133.0	26000.	27369.	36100.
422.	.08	134.2	25807.	28500.	34900.
442.	-.17	136.7	23729.	27062.	32250.
462.	0.0	140.4	21223.	23951.	29600.
482.	.037	140.5	20298.	21773.	30250.
502.	.055	143.0	18654.	22044.	30900.
522.	.24	151.05	14997.	24606.	31000.
544.5	.51	153.8	13262.	24085.	RAMP
567.	.58	157.3	10527.	23000.	RAMP
589.5	.61	162.1	7537.	20154.	RAMP
612.	.62	165.9	5473.	17879.	2062.
650.5	-.034	178.3	1159.	15378.	1762.
689.5	-.55	179.0	990.	8578.	1503.
706.	-.54	179.0	1062.	7[illegible]73.	1396.
736.9	-6.04	180.75	1190.	6063.	1730.
746.9	-4.3	179.6	2285.	11416.	1491.

TABLE 21
LUMPED SKIN AND STRINGER AXIAL AREAS, 30 STRINGER MODEL
FS 262-442

				262		282		302		327
STR	#	Y (BL)	Z (WL)	A	t	A	t	A	t	
RHS	1	0.	191.	.2398	.025	.2554	.025	.3604	.04	
	2	-7.	191.	1.1370	.025	.7671	.025	1.7414	.04	
	3	-20.	191.	1.3630	.025	.8610	.025	1.5128	.04	3.
	4	-31.81	189.7	.6391	.025	.6061	.025	.8363	.04	.
	5	-43.5	184.	.6572	.027	.6613	.0335	1.099	.048	.
	6	-50.42	174.69	.4839	.0295	.5964	.036	.7607	.042	.
	7	-51.98	163.	.7250	.032	.8808	.032	.9116	0.	.
	8	-52.64	151.	.5451	.032	.5451	.032	0.	0.	.
	9	-52.92	139.	.7143	.032	.8268	.032	.7268	.032	.
	10	-53.	127.	.7290	.032	.7290	.032	.8876	.032	.
	11	-52.58	109.	.8202	.0296	.8201	.0296	1.3455	.0296	1.
	12	-48.	92.	.79595	.025	.9947	.025	.8264	.025	1.
	13	-35.7	87.15	.6714	.025	.6714	.025	.6715	.025	.
	14	-16.44	87.	.6865	.025	.6865	.025	.6865	.025	.
	15	-4.62	87.	.3704	.025	.3704	.025	2.364	.025	3.
	16	0.	87.	.3543	.025	.3543	.025	.3543	.025	
	17	10.96	87.	.4868	.025	.4868	.025	.4868	.025	.
	18	19.44	87.01	.5050	.025	.5050	.025	.5050	.025	.
	19	35.70	87.15	.5805	.025	.5805	.025	.5805	.025	.
	20	48.	92.	.7695	.025	.9684	.025	.8610	.034	1.
	21	52.58	109.	.6935	.025	.6935	.025	1.4373	.032	1.
	22	53.	127.	.6580	.032	.6580	.032	.9813	.032	.
	23	52.92	139.	.7143	.032	.8268	.032	.7473	0.	.
	24	52.64	151.	.5450	.032	.5451	.032	0.	0.	.
	25	51.98	163.	.7270	.0295	.8634	.036	.9147	.036	.
	26	50.42	174.69	.4860	.027	.5790	.0335	.7637	.048	.
	27	43.5	184.	.6622	.0250	.6663	.025	1.092	.040	.
	28	31.81	189.7	.6391	.025	.6061	.025	.8513	.045	.
	29	20.	191.	.9321	.025	.9865	.025	1.7708	.050	3.
LHS	30	7.	191.	.8304	.025	.5889	.025	1.6358	0.	0.

651195

302 A	t	327 A	t	342 A	t	362 A	t	382 A	t	402 A	t	422 A	t (442)
.3604	.04	0.	0.	0.	0.	.2622	.032	.2754	.025	.2554	.025	.2554	.025
1.7414	.04	0.	0.	0.	0.	1.5455	.050	.6712	.025	.3713	.025	.5843	.025
1.5128	.04	3.1227	.04	3.1227	.04	1.6426	.040	.7411	.025	.5808	.025	.5803	.025
.8363	.04	.8278	.04	.826	.04	.7691	.032	.6605	.032	.6148	.0285	.6022	.025
1.099	.048	.6276	.048	.770	.04	1.0192	.036	.6199	.032	.6174	.039	.5075	.025
.7607	.042	.7469	.049	.654	.04	.7718	.040	.5895	.032	.6538	.038	.493	.0285
.9116	0.	.8596	.032	.657	.032	.6861	.040	.6867	.0305	.4975	0.	.8383	.036
0.	0.	.5793	.032	.540	.032	.6409	.032	.6377	.0425	0.	0.	.6903	.040
.7268	.032	.8030	.05	.644	.04	.5655	.032	.7359	.040	.4362	.040	.7787	.032
.8876	.032	.9970	.032	.889	.032	.660	.032	.9457	.040	.9462	.0433	.8977	.0433
1.3455	.0296	1.095	.0296	1.009	.0296	.8320	.032	1.0663	.040	1.1263	.040	1.5573	.0467
.8264	.025	1.066	.025	1.0659	.025	1.0576	.032	1.9128	.036	1.9158	.032	2.0113	.032
.6715	.025	.6804	.025	.6799	.025	.7801	.0297	.7979	.0213	.7849	.0297	.7849	.0297
.6865	.025	.6805	.025	.6806	.025	.7055	.025	.6672	.025	.6603	0.	.7826	.025
2.364	.025	3.8123	0.	1.979	.041	.4192	.050	.3704	.025	.1596	0.	.3704	.025
.3543	.025	0.	0.	1.1924	.033	1.2445	.0375	.3332	.0225	.1596	0.	.3538	.025
.4868	025	.125	0.	.5159	.025	.5400	.025	.5009	.025	.2886	.0125	.5178	.025
.5050	.025	.4742	.025	.4787	.025	.5325	.032	.5695	.032	.5400	.0285	.5637	.0285
.5805	.025	.6207	.025	.6049	.025	.6724	.032	.6959	.036	.6782	.032	.6777	.032
.8610	.034	1.0859	.0296	1.0709	.0296	1.0572	.032	1.9056	.040	1.9158	.040	2.0113	.0466
1.4373	.032	1.1020	.032	.9870	.032	.8130	.032	1.0665	.040	1.1263	.0433	1.2283	.0433
.9813	.032	.9930	.050	.8855	.040	.660	.032	.9457	.040	.9612	.045	.8977	.032
.7473	0.	.8030	.032	.644	.032	.582	.036	.777[illegible]	.046	.4812	0.	.8387	.050
0.	0.	.5793	.032	.540	.032	.7274	.045	.7287	.042	0.	0.	.8003	.041
.9147	.036	.8596	.049	.6586	.040	.7011	.040	.7731	.040	.5177	.0385	.8583	.0285
.7637	.048	.7771	.048	.6857	.040	.7837	.040	.6606	.036	.6901	.0415	.4930	.025
1.092	.040	.8577	.04	.8186	.04	.896	.036	.6207	.032	.6501	.0285	.5975	.025
.8513	.045	.8278	.04	.8659	.04	.7523	.036	.6605	.025	.6150	.025	.6011	025
1.7708	.050	3.1910	0.	3.1910	0.	1.4305	.050	.6701	.025	.5810	.025	.5785	.025
1.6388	0.	0.	0.	0.	0.	1.4955	.032	.6202	.025	.4343	.025	.5839	.025

TABLE 22

LUMPED SKIN AND STRINGER AXIAL AREAS, 62 STRINGERS, FS 262-442

STR #	B.L. Y	W.L. Z	262–282	282–302	302–322	322–342	342–362	362–382	382–402	402–422	422–442
1	0.	191.0	.2398	.2554	.3604	0.	0.	0.2682	0.2754	.2554	.2554
2	-7.0	191.0	.6748	.6495	1.570	0.	0.	1.347	.460	.2499	[illegible]
3	-13.0	191.0	.9245	.2485	.3428	0.	0.	.397	.4225	.2429	.2429
4	-20.0	191.0	.7185	.5875	1.1862	2.885	2.888	1.253	.3675	.3109	.3109
5	-26.0	190.76	.3646	.2986	.4456	.4694	.4694	.3822	.3249	.2969	.2969
6	-31.81	189.7	.3003	.3003	.4022	.3886	.3886	.332	.3201	.2986	.2989
7	-37.59	187.67	.3131	.3131	.4226	.4090	.4090	.4931	.3571	.3356	.3114
8	-43.5	184.0	.3880	.3719	.6959	.4360	.4010	.5111	.2825	.2825	.2383
9	-47.56	180.0	.2254	.2657	.3836	.3742	.3304	.5252	.3188	.3342	.2291
10	-50.42	174.5	.2238	.3004	.3787	.3713	.3280	.3396	.2880	.3258	.2467
11	-51.38	169.0	.2948	.3264	.3804	.3771	.3229	.3402	.2853	.3219	.2657
12	-52.98	163.0	.4413	.5813	.7214	.4969	.3618	.3508	.3832	.3366	.5246
13	-52.38	157.0	.2727	.2727	[illegible]	.3483	.2703	.3304	.3128	0.	.3629
14	-52.64	151.0	.2726	.2726	0.	.2702	.2702	.3122	.3011	0.	.3397
15	-52.82	145.0	.2724	.2724	0.	.2700	.2700	.3270	.3605	0.	.3395
16	-52.91	139.0	.4419	.5544	.5064	.4430	.3260	[illegible]	.3685	.2665	.4643
17	-52.98	133.0	.2724	.2724	.4408	.4500	.3670	.2640	.3395	.3395	.2915
18	-53.0	127.0	.3204	.3204	.3204	.4100	.3570	.2640	.437	.4370	.4130
19	-52.96	121.0	.2724	.2724	.3468	.3620	.3490	.2640	.3395	.3395	.3395
20	-52.84	115.0	.2726	.2725	.3469	.3492	.3492	.2612	.3397	.3697	.3697
21	-52.57	109.0	.2730	.2730	.6240	.3546	.2946	[illegible]	.3403	.3703	.7295
22	-52.01	103.0	.2746	.2746	.3746	.3912	.3652	.3032	.3863	.3863	.4580
23	-50.84	97.0	.4412	.5592	.4412	.6673	.6673	.5951	.6243	.6103	.6468
24	-48.0	92.0	.2186	.2994	.2490	.2612	.2612	.3950	1.1162	1.1467	1.2052
25	-42.12	88.68	.2723	.2723	.2724	.2759	.2759	.3287	.3457	.3187	.3187
26	-35.7	87.55	.2683	.2683	.2683	.2719	.2719	.3072	.3163	.3136	.3136
27	-29.28	87.13	.2670	.2670	.2670	.2706	.2706	.3056	.3120	.3120	.3120
28	-22.86	87.01	.3044	.3044	.3044	.2795	.2795	.3310	.2973	.3374	.3374
29	-16.44	87.0	.2551	.2551	.2551	.2677	.2677	.2500	.2479	.2697	.3182
30	-10.90	87.0	.2541	.2541	.2541	.2667	.2667	.2490	.2541	.1064	.2541
31	-4.62	87.0	.2434	.2434	2.237	3.679	1.846	.2947	.2434	.1064	.2434

TABLE 22 (continued)

STR #	B.L.	W.L. Z	262	282	302	322	342	362	382	402	422	442
32	0.0	87.0	.2326	.2326	.2326	0.	1.047	1.092	.2189	.1064	.2326	
33	5.48	87.0	.2434	.2434	.2434	0.	.2908	.3055	.2297	.1064	.2434	
34	10.96	87.0	.2434	.2434	.2434	0.125	.2470	.2370	.2434	.1064	.2434	
35	16.44	87.0	.2434	.2434	.2434	0.	.2470	.2370	.2864	.258	.3065	
36	22.86	87.01	.2499	.2499	.2499	.3345	.2160	.2645	.2709	.2604	.2604	
37	29.28	87.22	.2669	.2669	.2669	.2795	.2795	.2997	.3188	.3013	.3013	
38	35.40	87.55	.3109	.3109	.3109	.3235	.3235	.3560	.3682	.3682	.3682	
39	42.12	88.69	.2723	.2723	.2723	.3149	.2849	.3343	.3457	.3187	.3187	
40	48.0	92.0	.2186	.3707	.2490	.2612	.2612	.2950	1.1126	1.1462	1.2052	
41	50.76	97.0	.4184	.4616	.4759	.6673	.6673	.5951	.6207	.6103	.6468	
42	52.02	103.0	.2321	.2321	[illegible]	.3892	.3632	.2842	.3863	.3863	.4580	
43	52.58	109.0	.2309	.2309	.6500	.3656	.2766	.2646	.3403	.3703	.4005	
44	52.84	115.0	.2305	.2305	.3600	.3472	.3472	.2642	.3397	.3697	.3697	
45	52.97	121.0	.2304	.2304	.3598	.3600	.3470	.2640	.3395	.3395	.3395	
46	53.0	127.0	.2914	.2914	.3806	.4080	.3550	.2640	.4370	.4370	.4130	
47	52.98	133.0	.2724	.2724	.4818	.4500	.3670	.2640	.3395	.3695	.2915	
48	52.92	139.0	.4419	.5544	.5064	.4430	.3260	.270	.3865	.2965	.4943	
49	52.82	145.0	.2724	.2724	0.	.2700	.2700	.360	.4455	0.	.3995	
50	52.64	151.0	.2725	.2726	0.	.2702	.2700	.3672	.3311	0.	.3997	
51	52.38	157.0	.2727	.2727	0.	.3483	.2702	.3604	.3519	0.	.4029	
52	51.98	163.0	.4413	.5813	.7215	.4969	.3618	.3508	.4324	.3547	.5446	
53	51.38	169.0	.2988	.2915	.3864	.3771	.3229	.3402	.3317	.3260	.2657	
54	50.42	174.7	.2239	.3004	.3787	.3914	.3491	.3396	.3351	.3273	.2467	
55	47.46	180.0	.2254	.2657	.3839	.3043	.3525	.5480	.3204	.3997	.2291	
56	43.50	184.0	.3930	.3769	.6889	.4561	.4261	.3576	.2825	.2825	.2383	
57	37.59	187.62	.3131	.3131	[illegible]	.4090	.4349	.5284	.3571	.3356	.3114	
58	31.81	189.7	.3003	.3003	.4022	.3886	.4145	.3088	.3201	.2986	.2986	
59	26.0	190.76	.3646	.2986	.4756	.4694	.4694	.3586	.3249	.2973	.2957	
60	20.0	191.0	.5823	.7062	1.2976	2.9568	2.9568	1.053	.3675	.3109	.3098	
61	13.0	191.0	.3350	.2623	.4709	0.	0.	.3970	.2805	.2429	.4629	
62	7.0	191.0	.6629	.4579	1.4034	0.	0.	1.297	.4800	.3129	.4629	

TABLE 22 (continued)

STR #	B.L.	W.L. Z	262	282	302	322	342	362	382	402	422	442
32	0.0	87.0	.2326	.2326	.2326	0.	1.047	1.092	.2189	.1064	.2326	
33	5.48	87.0	.2434	.2434	.2434	0.	.2908	.3055	.2297	.1064	.2434	
34	10.96	87.0	.2434	.2434	.2434	0.125	.2470	.2370	.2434	.1064	.2434	
35	16.44	87.0	.2434	.2434	.2434	0.	.2470	.2370	.2864	.258	.3065	
36	22.86	87.01	.2499	.2499	.2499	.3345	.2160	.2645	.2709	.2604	.2604	
37	29.28	87.22	.2669	.2669	.2669	.2795	.2795	.2997	.3188	.3013	.3013	
38	35.40	87.55	.3109	.3109	.3109	.3235	.3235	.3560	.3682	.3682	.3682	
39	42.12	88.69	.2723	.2723	.2723	.3149	.2849	.3343	.3457	.3187	.3187	
40	48.0	92.0	.2186	.3707	.2490	.2612	.2612	.2950	1.1126	1.1462	1.2052	
41	50.76	97.0	.4184	.4616	.4759	.6673	.6673	.5951	.6207	.6103	.6468	
42	52.02	103.0	.2321	.2321	.4[illegible]73	.3892	.3632	.2842	.3863	.3863	.4580	
43	52.58	109.0	.2309	.2309	.6500	.3656	.2766	.2646	.3403	.3703	.4005	
44	52.84	115.0	.2305	.2305	.3600	.3472	.3472	.2642	.3397	.3697	.3697	
45	52.97	121.0	.2304	.2304	.3598	.3600	.3470	.2640	.3395	.3395	.3395	
46	53.0	12[illegible].0	.2914	.2914	.3806	.4[illegible]80	.3550	.2640	.4370	.4370	.4130	
47	52.98	13[illegible].0	.2724	.2724	.481[illegible]	.4500	.3670	.2640	.3395	.3695	.2915	
48	52.92	139.0	.4419	.5544	.5064	.4430	.3260	.270	.3865	.2965	.4943	
49	52.82	145.0	.2724	.2724	0.	.2700	.2700	.360	.4455	0.	.3995	
50	52.64	151.0	.2725	.2726	0.	.2702	.2700	.3672	.3311	0.	.3997	
51	52.38	157.0	.2727	.2727	0.	.3483	.2702	.3604	.3519	0.	.4029	
52	51.98	163.0	.4413	.5813	.7215	.4969	.3618	.3508	.4324	.3547	.5446	
53	51.38	169.0	.2988	.2915	.3864	.3771	.3229	.3402	.3317	.3260	.2657	
54	50.42	174.7	.2239	.3004	.3787	.3914	.3491	.3396	.3351	.3273	.2467	
55	47.46	180.0	.2254	.2657	.38[illegible]	.3043	.3525	.5480	.3204	.3997	.2291	
56	43.50	184.0	.3930	.3769	.6889	.4561	.4261	.3576	.2825	.2825	.2383	
57	37.59	187.62	.3131	.3131	.4[illegible]	.40[illegible]0	.4349	.5284	.3571	.3356	.3114	
58	31.81	189.7	.3003	.3003	.4022	.3886	.4145	.3088	.3201	.2986	.2986	
59	26.0	190.76	.3646	.2986	.4756	.4694	.4694	.3586	.3249	.2973	.2957	
60	20.0	191.0	.5823	.7062	1.2976	2.9568	2.9568	1.053	.3675	.3109	.3098	
61	13.0	191.0	.3350	.2620	.4709	0.	0.	.3970	.2805	.2429	.4629	
62	7.0	191.0	.6629	.4579	1.4034	0.	0.	1.297	.4800	.3129	.4629	

MODEL, FS 262-442

282		302		322		342		362		382		
I	A	I	A	I	A	I	A	I	A	I	A	I
7.0	.54	21.46	.91	352.	13.16	0.0	0.0	352.8	11.81	22.57	1.01	9.6
1.74	.38	21.46	.90	344.4	13.20	0.0	0.0	414.0	14.36	23.6	1.025	9.0
5.72	.49	22.09	1.59	220.0	8.45	67.95	1.76	239.5	9.34	33.45	1.50	9.9
6.925	.54	15.68	1.785	118.6	6.74	10.7	.83	129.3	7.475	39.55	1.85	6.1
1.435	.40	8.77	2.77	37.78	5.85	2.775	.785	31.25	5.29	11.70	1.78	1.7
.635	.355	6.88	3.13	16.85	6.335	1.38	.70	12.95	4.235	5.45	1.485	.9
.63	.36	2.435	1.295	12.31	3.635	1.235	.64	11.79	3.88	5.66	1.55	1.0
.73	.415	2.035	1.085	7.645	2.025	1.31	.655	5.65	1.765	6.65	1.845	1.0
.805	.452	2.075	1.13	5.495	1.50	1.50	.74	4.925	1.415	51.8	3.8	1.0
1.05	.545	1.81	.94	5.39	1.586	2.18	.98	4.30	1.196	52.46	3.48	1.1
3.19	1.20	8.63	2.36	9.52	2.04	5.41	1.62	10.46	2.246	43.3	2.616	3.2
6.715	1.29	8.375	2.30	16.57	2.04	11.66	1.695	9.77	1.845	21.4	2.635	6.2
6.43	1.10	11.71	2.06	19.83	1.566	20.85	1.64	10.67	1.12	15.67	1.64	9.0
9.99	.99	12.06	1.215	30.80	2.195	35.65	2.515	11.65	1.14	15.25	1.44	9.
9.96	.98	13.85	1.38	51.22	4.54	54.48	4.47	11.80	1.17	14.7	1.30	9.9
9.96	.98	12.3	1.19	43.67	3.515	46.02	4.415	11.75	1.16	14.9	1.35	9.9
10.14	1.03	13.67	1.68	31.96	2.24	33.31	2.417	11.53	1.23	15.46	1.493	9.9
9.642	1.102	12.52	1.61	22.03	1.73	19.70	1.566	10.52	1.126	15.68	1.664	9.8
6.715	1.29	8.375	2.30	16.57	2.04	11.66	1.695	9.77	1.845	21.4	2.635	6.2
3.19	1.20	8.50	2.40	9.52	2.04	5.41	1.62	10.42	2.27	43.3	2.616	3.2
1.05	.545	1.81	.94	5.39	1.586	2.18	.98	4.24	1.17	52.46	3.48	1.1
.805	.452	2.075	1.13	5.495	1.50	1.50	.74	3.585	1.225	51.8	3.8	1.0
.73	.415	2.035	1.085	7.645	2.025	1.31	.655	4.42	1.56	6.65	1.845	1.0
.63	.36	2.435	1.295	12.31	3.635	1.235	.64	6.275	2.30	5.66	1.55	1.0
.635	.355	6.88	3.13	16.85	6.335	1.38	.70	12.55	4.015	5.45	1.485	.9
1.435	.40	8.77	2.77	37.78	5.85	2.775	.785	23.74	4.535	11.70	1.78	1.7
6.925	.54	15.68	1.785	118.6	6.74	10.7	.83	107.6	6.465	39.55	1.85	6.1
11.325	.607	22.09	1.59	220.0	8.45	67.95	1.76	223.7	10.63	33.45	1.50	9.9
12.17	.645	21.46	.86	344.4	13.20	0.0	0.0	405.1	14.02	23.6	1.025	9.0
12.18	.69	21.46	.89	352.	13.16	0.0	0.0	352.8	11.81	22.57	1.01	9.6

342		362		382		402		422		442	
I	A	I	A	I	A	I	A	I	A	I	A
0.0	0.0	352.8	11.81	22.57	1.01	9.68	.44	7.179	.238	33.82	1.113
0.0	0.0	414.0	14.36	23.6	1.025	9.05	.425	7.298	.305	33.82	1.113
67.95	1.76	239.5	9.34	33.45	1.50	9.95	.575	6.533	.209	43.85	1.767
10.7	.83	129.3	7.475	39.55	1.85	6.19	.475	5,783	.54	40.5	2.47
2.775	.785	31.25	5.29	11.70	1.78	1.745	.485	1.509	.445	14.75	2.22
1.38	.70	12.95	4.235	5.45	1.485	.965	.470	1.052	.513	20.17	2.28
1.235	.64	11.79	3.88	5.66	1.55	1.03	.495	1.2	.519	26.	2.6
1.31	.655	5.65	1.765	6.65	1.845	1.01	.485	1.337	.559	36.83	3.53
1.50	.74	4.925	1.415	51.8	3.8	1.015	.485	1.079	.5	53.16	4.89
2.18	.98	4.30	1.196	52.46	3.48	1.176	.513	1.281	.528	159.3	6.87
5.41	1.62	10.46	2.246	43.3	2.616	3.25	.96	3.25	.96	128.6	5.48
11.66	1.695	9.77	1.845	21.4	2.635	6.215	1.11	6.215	1.11	39.3	4.91
20.85	1.64	10.67	1.12	15.67	1.64	9.816	1.01	9.8	1.06	32.7	2.7
35.65	2.515	11.65	1.14	15.25	1.44	9.95	.90	9.92	.91	20.58	1.546
54.48	4.47	11.80	1.17	14.7	1.30	9.90	.89	9.9	.89	19.37	1.45
46.02	4.415	11.75	1.16	14.9	1.35	9.90	.89	9.9	.89	18.96	1.47
33.31	2.417	11.53	1.23	15.46	1.493	9.95	.913	9.95	.913	21.59	1.57
19.70	1.566	10.52	1.126	15.68	1.664	9.81	1.032	9.81	1.032	32.7	2.7
11.66	1.695	9.77	1.845	21.4	2.635	6.215	1.11	6.21	1.11	39.3	4.91
5.41	1.62	10.42	2.27	43.3	2.616	3.25	.96	3.25	.96	128.6	5.48
2.18	.98	4.24	1.17	52.45	3.48	1.176	.513	1.281	.528	159.3	6.87
1.50	.74	3.585	1.225	51.8	3.8	1.015	.485	1.079	.5	53.16	4.89
1.31	.655	4.42	1.56	6.65	1.845	1.01	.485	1.337	.559	36.83	3.53
1.235	.64	6.275	2.30	5.66	1.55	1.03	.495	1.2	.519	26.	2.6
1.38	.70	12.55	4.015	5.45	1.485	.965	.470	1.052	.513	20.17	2.28
2.775	.785	23.74	4.535	11.70	1.78	1.745	.485	1.509	.445	14.75	2.22
10.7	.83	107.6	6.465	39.55	1.85	6.19	.495	6.278	.507	40.5	2.47
67.95	1.76	223.7	10.63	33.45	1.50	9.95	.575	7.029	.271	45.	1.767
0.0	0.0	405.1	14.02	23.6	1.025	9.05	.425	7.298	.305	33.82	1.113
0.0	0.0	352.8	11.81	22.57	1.01	9.68	.44	7.179	.238	33.82	1.113

TABLE 24
SIX BAY REDUCED DEGREE OF FREEDOM MODEL MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	.9865	2	1.1718	3	.7264
4	.4572	5	.3079	6	.2598
7	.7052	8	.4914	9	.3170
10	.6050	11	.3633	12	.3739
13	.4715	14	.9865	15	1.1718
16	.7264	17	.4572	18	.3079
19	.2598	20	.7052	21	.4914
22	.3170	23	.6050	24	.3633
25	.3739	26	.4715	27	.9865
28	1.1718	29	.7264	30	.4572
31	.3079	32	.2598	33	.7052
34	.4914	35	.3170	36	.6050
37	.3633	38	.3739	39	.4715
40	1157.9999	41	2440.0000	42	2155.0000
43	1377.0000	44	935.0000	45	814.0000
46	2124.0000	47	1465.9999	48	925.0000
49	1399.0000	50	567.0000	51	263.0000
52	189.0000	53	533.0000	54	1215.9999
55	1090.0000	56	757.0000	57	549.0000
58	427.0000	59	1138.0000	60	748.0000
61	533.0000	62	679.0000	63	155.0000
64	42.0000	65	45.0000	66	625.0000
67	1228.0000	68	1096.9999	69	626.0000
70	391.0000	71	392.0000	72	993.0000
73	741.0000	74	412.0000	75	1143.0000
76	458.0000	77	274.0000	78	156.0000
79	.2663	80	.0475	81	.0475
82	.0658	83	.0412	84	.0412
85	.0858	86	.1709	87	.0441
88	.0441	89	.1709	90	.0934
91	.0641	92	.0641	93	.0934
94	.1535	95	.0503	96	.0503
97	.1535	98	.0357	99	.0357
100	.1100	101	.0551	102	.0551
103	.1100	104	.2613	105	.2663
106	.0949	107	.0858	108	.0825
109	.0858	110	.1709	111	.0882
112	.1709	113	.0934	114	.1282
115	.0934	116	.1535	117	.1005
118	.1535	119	.0714	120	.1100
121	.1101	122	.1100	123	.2613

TABLE 24 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
124	.2663	125	.0949	126	.0443
127	.0416	128	.0825	129	.0416
130	.0443	131	.1164	132	.0392
133	.0882	134	.0392	135	.1164
136	.0466	137	.0468	138	.1282
139	.0468	140	.0466	141	.1001
142	.0534	143	.1005	144	.0534
145	.1001	146	.0714	147	.0551
148	.0570	149	.1101	150	.0570
151	.0531	152	.2613	153	778.0000
154	428.0000	155	355.0000	156	804.0000
157	447.0000	158	361.0000	-0	-.0000
159	4.6308	160	4.6308	161	4.6308
162	2601.2600	163	2477.8800	164	1767.0500

TABLE 25
NINE BAY MODEL MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	.9865	2	1.1718	3	.7264
4	.4572	61	.3079	-0	-.0000
104	.7052	5	.4914	6	.3170
7	.6050	8	.3633	9	.3739
10	.4715	11	.9865	12	1.1718
13	.7264	14	.4572	105	.3079
135	.7052	15	.4914	-0	-.0000
16	.3170	17	.6050	18	.3633
19	.3739	20	.4715	21	.9865
22	1.1718	23	.7264	24	.4572
25	.4914	26	.3170	27	.6050
28	.3633	29	.3739	30	.4715
31	1157.9999	32	2440.0000	33	2155.0000
34	1377.0000	183	935.0000	-0	-.0000
186	2124.0000	35	1465.9999	36	925.0000
37	1399.0000	38	567.0000	39	263.0000
40	169.0000	41	533.0000	42	1215.9999
43	1090.0000	44	757.0000	184	549.0000
187	1138.0000	45	748.0000	-0	-.0000
46	533.0000	47	679.0000	48	155.0000
49	42.0000	50	45.0000	51	625.0000
52	1228.0000	53	1096.9999	54	626.0000
55	741.0000	56	412.0000	57	1143.0000
58	458.0000	59	274.0000	60	156.0000
62	.0346	63	.0346	64	.0618
65	.0367	66	.0367	67	.0618
68	.0475	69	.0475	-0	-.0000
70	.0858	71	.0412	72	.0412
73	.0858	74	.1709	75	.0441
76	.0441	77	.1709	78	.0934
79	.0641	80	.0641	81	.0934
82	.1535	83	.0503	84	.0503
85	.1535	86	.0357	87	.0357
88	.1100	89	.0551	90	.0551
91	.1100	-0	-.0000	-0	-.0000
92	.0298	93	.0298	94	.0665
95	.0344	96	.0344	97	.0665
98	.0268	99	.0268	100	.0652
101	.0379	102	.0379	103	.0652
106	.0693	107	.0618	108	.0735
109	.0618	-0	-.0000	-0	-.0000

TABLE 25 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
110	.0949	111	.0858	112	.0825
113	.0658	114	.1709	115	.0882
116	.1709	117	.0934	118	.1282
119	.0934	120	.1535	121	.1005
122	.1535	123	.0714	124	.1100
125	.1101	126	.1100	-0	-.0000
127	.0596	128	.0665	129	.0688
130	.0665	131	.0535	132	.0652
133	.0759	134	.0652	-0	-.0000
136	.3079	162	.7052	-0	-.0000
137	.0693	138	.0327	139	.0291
140	.0735	141	.0291	142	.0327
143	.0949	144	.0443	-0	-.0000
145	.0416	146	.0625	147	.0416
148	.0443	149	.1164	150	.0392
151	.0882	152	.0392	153	.1164
154	.0466	155	.0468	156	.1282
157	.0468	158	.0466	159	.1001
160	.0534	161	.1005	162	.0534
163	.1001	164	.0714	165	.0551
166	.0570	167	.1101	168	.0570
169	.0531	-0	-.0000	-0	-.0000
170	.0596	171	.0340	172	.0325
173	.0682	174	.0325	175	.0340
176	.0535	177	.0325	178	.0327
179	.0759	180	.0327	181	.0325
185	391.0000	186	993.0000	-0	-.0000
189	4.6308	190	4.6308	191	4.6308
192	2681.2600	193	2477.8800	194	1767.0500

TABLE 26
EIGHTEEN BAY MODEL, PHASE 1, MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	.9865	2	1.1718	3	.7264
4	.4572	36	.3079	-0	-.0000
160	.3633	5	.3739	-0	-.0000
6	.4715	7	.9865	8	1.1718
9	.9550	-0	-.0000	-0	-.0000
10	.3739	11	.4715	12	.9865
13	1.1718	14	.7264	15	.4572
190	.3633	16	.3739	17	.4715
18	1157.9999	19	2440.0000	20	2155.0000
21	1377.0000	136	935.0000	-0	-.0000
191	567.0000	22	263.0000	-0	-.0000
23	189.0000	24	533.0000	25	1215.9999
26	1090.0000	27	757.0000	139	549.0000
28	42.0000	29	45.0000	30	625.0000
31	1228.0000	32	1096.9999	33	626.0000
193	458.0000	34	274.0000	35	156.0000
37	.0346	38	.0346	39	.0618
40	.0367	41	.0367	42	.0618
43	.0475	44	.0475	-0	-.0000
45	.0858	46	.0412	47	.0412
48	.0858	49	.1709	50	.0441
51	.0441	52	.1709	53	.0934
54	.0641	55	.0641	56	.0934
57	.1535	58	.0503	59	.0503
60	.1535	61	.0357	62	.0357
63	.1100	64	.0551	65	.0551
66	.1100	-0	-.0000	-0	-.0000
67	.0392	68	.0392	69	.1041
70	.0523	71	.0523	72	.1045
73	.8351	[illegible]	.6696	-0	-.0000
75	.1295	76	.1167	77	.1193
78	.1167	79	.1709	80	.0882
81	.1709	82	.0934	83	.1282
84	.0934	85	.1535	86	.1005
87	.1535	88	.0714	89	.1100
90	.1101	91	.1100	-0	-.0000
92	.0785	93	.1041	94	.1045
95	.1041	96	.8351	-0	-.0000
97	.3079	137	.8351	-0	-.0000
98	.0693	99	.0327	100	.0291
101	.0735	102	.0291	103	.0327

TABLE 26 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
104	.0949	105	.0443	-0	-.0000
106	.0416	107	.0825	108	.0416
109	.0443	110	.1164	111	.0392
112	.0882	113	.0392	114	.1164
115	.0466	116	.0468	117	.1282
118	.0468	119	.0466	120	.1001
121	.0534	122	.1005	123	.0534
124	.1001	125	.0714	126	.0551
127	.0570	128	.1101	129	.0570
130	.0531	-0	-.0000	-0	-.0000
131	.0785	132	.0563	133	.0479
134	.1045	135	.0479	136	.0563
140	391.0000	-0	-.0000	-0	-.0000
141	2531.0000	142	1351.0000	143	1188.9999
144	.0629	145	.0629	146	.0938
147	.0890	148	.0890	149	.0938
150	.0350	151	.0350	152	.0706
153	.0529	154	.0529	155	.0706
156	.0610	157	.0610	158	.2415
159	.2415	-0	-.0000	-0	-.0000
161	.1259	162	.0938	163	.1781
164	.0938	165	.0700	166	.0706
167	.1057	168	.0706	169	.1220
170	.2415	171	.2415	-0	-.0000
172	.3633	-0	-.0000	-0	-.0000
173	.1259	174	.0558	175	.0379
176	.1781	177	.0379	178	.0558
179	.0700	180	.0369	181	.0337
182	.1057	183	.0337	184	.0369
185	.1220	186	.1410	187	-.0000
188	-.0000	189	.1410	-0	-.0000
192	155.0000	-0	-.0000	-0	-.0000
194	4.6308	195	4.6308	196	4.6308
197	2681.2600	198	2477.8600	199	1767.0500

TABLE 27
GEOMETRY AND STRUCTURAL DATA FOR RAMP AREA PPFRAN MODEL

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	1	632.00	.00	187.50
JOINT	2	632.00	-6.80	192.50
JOINT	3	632.00	-20.00	192.30
JOINT	4	632.00	-26.00	191.70
JOINT	5	632.00	-37.00	187.00
JOINT	6	632.00	-47.80	170.00
JOINT	7	632.00	-48.90	163.00
JOINT	8	632.00	-49.40	156.00
JOINT	9	632.00	-49.60	147.00
JOINT	10	632.00	-49.60	146.00
JOINT	11	632.00	-49.60	145.00
JOINT	12	632.00	-35.00	170.00
JOINT	13	632.00	-26.00	170.00
JOINT	14	632.00	-15.00	170.00
JOINT	15	532.00	-7.00	170.00
JOINT	16	632.00	.00	170.00
JOINT	17	632.00	7.00	170.00
JOINT	18	632.00	15.00	170.00
JOINT	19	632.00	26.00	170.00
JOINT	20	632.00	35.00	170.00
JOINT	21	632.00	49.60	145.00
JOINT	22	632.00	49.60	146.00
JOINT	23	632.00	49.60	147.00
JOINT	24	632.00	49.40	156.00
JOINT	25	632.00	48.90	163.00
JOINT	26	632.00	47.80	170.00
JOINT	27	332.00	37.00	187.00
JOINT	28	632.00	26.00	191.70
JOINT	29	632.00	20.00	192.30
JOINT	30	632.00	6.80	192.50
JOINT	31	612.00	.00	188.00
JOINT	32	612.00	-6.80	192.30
JOINT	33	612.00	-20.00	192.10
JOINT	34	612.00	-27.10	191.10
JOINT	35	612.00	-38.50	186.40
JOINT	36	612.00	-49.50	170.00
JOINT	37	612.00	-50.60	163.00
JOINT	38	612.00	-51.10	156.90
JOINT	39	612.00	-51.50	139.00
JOINT	40	612.00	-51.00	136.90
JOINT	41	612.00	-51.00	135.90
JOINT	42	612.00	-38.50	170.00
JOINT	43	612.00	-29.00	170.00
JOINT	44	612.00	-17.50	170.00
JOINT	45	612.00	-6.84	170.00
JOINT	46	612.00	.00	170.00
JOINT	47	612.00	6.84	170.00
JOINT	48	612.00	17.50	170.00
JOINT	49	612.00	29.00	170.00
JOINT	50	612.00	38.50	170.00

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	51	612.00	51.00	135.90
JOINT	52	612.00	51.00	136.90
JOINT	53	612.00	51.50	139.00
JOINT	54	612.00	51.10	156.90
JOINT	55	612.00	50.60	163.00
JOINT	56	612.00	49.50	170.00
JOINT	57	612.00	38.50	186.40
JOINT	58	612.00	27.10	191.10
JOINT	59	612.00	20.00	192.10
JOINT	60	612.00	6.80	192.30
JOINT	61	589.50	.00	187.60
JOINT	62	589.50	-6.80	190.90
JOINT	63	589.50	-20.00	190.90
JOINT	64	589.50	-28.20	189.60
JOINT	65	589.50	-39.75	183.90
JOINT	66	589.50	-50.30	169.00
JOINT	67	589.50	-51.30	163.00
JOINT	68	589.50	-51.90	157.00
JOINT	69	589.50	-52.30	139.00
JOINT	70	589.50	-51.85	127.40
JOINT	71	589.50	-51.85	126.40
JOINT	72	589.50	-41.45	126.40
JOINT	73	589.50	-31.05	126.40
JOINT	74	589.50	-20.65	126.40
JOINT	75	589.50	-10.25	126.40
JOINT	76	589.50	.15	126.40
JOINT	77	589.50	10.55	126.40
JOINT	78	589.50	20.95	126.40
JOINT	79	589.50	31.35	126.40
JOINT	80	589.50	41.75	126.40
JOINT	81	589.50	51.85	126.40
JOINT	82	589.50	51.85	127.40
JOINT	83	589.50	52.30	139.00
JOINT	84	589.50	51.90	157.00
JOINT	85	589.50	51.30	163.00
JOINT	86	589.50	50.35	169.00
JOINT	87	589.50	39.75	183.90
JOINT	88	589.50	28.20	189.60
JOINT	89	589.50	20.00	190.90
JOINT	90	589.50	6.80	190.90
JOINT	91	567.00	.00	188.50
JOINT	92	567.00	-6.80	190.90
JOINT	93	567.00	-20.00	190.90
JOINT	94	567.00	-29.50	189.60
JOINT	95	567.00	-41.20	183.90
JOINT	96	567.00	-50.75	169.00
JOINT	97	567.00	-51.65	163.00
JOINT	98	567.00	-52.10	157.00
JOINT	99	567.00	-52.50	139.00
JOINT	100	567.00	-52.20	121.00

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	101	567.00	-52.00	116.70
JOINT	102	567.00	-41.60	116.70
JOINT	103	567.00	-31.20	116.70
JOINT	104	567.00	-20.80	116.70
JOINT	105	567.00	-10.40	116.70
JOINT	106	567.00	-.00	116.70
JOINT	107	567.00	10.40	116.70
JOINT	108	567.00	20.80	116.70
JOINT	109	567.00	31.20	116.70
JOINT	110	567.00	41.60	116.70
JOINT	111	567.00	52.00	116.70
JOINT	112	567.00	52.20	121.00
JOINT	113	567.00	52.50	139.00
JOINT	114	567.00	52.10	157.00
JOINT	115	567.00	51.65	163.00
JOINT	116	567.00	50.75	169.00
JOINT	117	567.00	41.20	183.90
JOINT	118	567.00	29.50	189.60
JOINT	119	567.00	20.00	190.90
JOINT	120	567.00	6.80	190.90
JOINT	121	544.50	.00	189.60
JOINT	122	544.50	-6.80	190.90
JOINT	123	544.50	-20.00	190.90
JOINT	124	544.50	-30.55	189.60
JOINT	125	544.50	-42.15	183.90
JOINT	126	544.50	-50.90	169.00
JOINT	127	544.50	-51.60	163.00
JOINT	128	544.50	-52.00	157.00
JOINT	129	544.50	-52.40	139.00
JOINT	130	544.50	-52.60	121.00
JOINT	131	544.50	-50.60	107.70
JOINT	132	544.50	-40.20	107.70
JOINT	133	544.50	-29.80	107.70
JOINT	134	544.50	-19.40	107.70
JOINT	135	544.50	-9.00	107.70
JOINT	136	544.50	1.40	107.70
JOINT	137	544.50	11.80	107.70
JOINT	138	544.50	22.20	107.70
JOINT	139	544.50	32.60	107.70
JOINT	140	544.50	43.00	107.70
JOINT	141	544.50	50.60	107.70
JOINT	142	544.50	52.60	121.00
JOINT	143	544.50	52.40	139.00
JOINT	144	544.50	52.00	157.00
JOINT	145	544.50	51.60	163.00
JOINT	146	544.50	50.90	169.00
JOINT	147	544.50	42.15	183.90
JOINT	148	544.50	30.55	189.60
JOINT	149	544.50	20.00	190.90
JOINT	150	544.50	6.80	190.90

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	151	522.00	-.00	191.00
JOINT	152	522.00	-6.75	191.00
JOINT	153	522.00	-20.00	191.00
JOINT	154	522.00	-31.81	189.70
JOINT	155	522.00	-43.50	184.00
JOINT	156	522.00	-51.38	169.00
JOINT	157	522.00	-51.98	163.00
JOINT	158	522.00	-52.38	157.00
JOINT	159	522.00	-52.91	139.00
JOINT	160	522.00	-52.96	121.00
JOINT	161	522.00	-50.79	97.00
JOINT	162	522.00	-48.00	92.00
JOINT	163	522.00	-35.70	87.60
JOINT	164	522.00	-22.86	87.10
JOINT	165	522.00	-10.96	87.00
JOINT	166	522.00	.00	87.00
JOINT	167	522.00	10.96	87.00
JOINT	168	522.00	22.86	87.10
JOINT	169	522.00	35.70	87.60
JOINT	170	522.00	48.00	92.00
JOINT	171	522.00	50.79	97.00
JOINT	172	522.00	52.96	121.00
JOINT	173	522.00	52.91	139.00
JOINT	174	522.00	52.37	157.00
JOINT	175	522.00	51.99	163.00
JOINT	176	522.00	51.38	169.00
JOINT	177	522.00	43.50	184.00
JOINT	178	522.00	31.81	189.70
JOINT	179	522.00	20.00	191.00
JOINT	180	522.00	6.75	191.00
JOINT	181	502.00	-.00	191.00
JOINT	182	502.00	-6.75	191.00
JOINT	183	502.00	-20.00	191.00
JOINT	184	502.00	-31.81	189.70
JOINT	185	502.00	-43.50	184.00
JOINT	186	502.00	-51.38	169.00
JOINT	187	502.00	-51.98	163.00
JOINT	188	502.00	-52.38	157.00
JOINT	189	502.00	-52.91	139.00
JOINT	190	502.00	-52.96	121.00
JOINT	191	502.00	-50.79	97.00
JOINT	192	502.00	-48.00	92.00
JOINT	193	502.00	-35.70	87.60
JOINT	194	502.00	-22.86	87.10
JOINT	195	502.00	-10.96	87.00
JOINT	196	502.00	.00	87.00
JOINT	197	502.00	10.96	87.00
JOINT	198	502.00	22.86	87.10
JOINT	199	502.00	35.70	87.60
JOINT	200	502.00	48.00	92.00

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	201	502.00	50.79	97.00
JOINT	202	502.00	52.96	121.00
JOINT	203	502.00	52.91	139.00
JOINT	204	502.00	52.37	157.00
JOINT	205	502.00	51.98	163.00
JOINT	206	502.00	51.38	169.00
JOINT	207	502.00	43.50	184.00
JOINT	208	502.00	31.81	189.70
JOINT	209	502.00	20.00	191.00
JOINT	210	502.00	6.75	191.00
JOINT	211	482.00	-.00	191.00
JOINT	212	482.00	-6.75	191.00
JOINT	213	482.00	-20.00	191.00
JOINT	214	482.00	-31.81	189.70
JOINT	215	482.00	-43.50	184.00
JOINT	216	482.00	-51.38	169.00
JOINT	217	482.00	-51.98	163.00
JOINT	218	482.00	-52.38	157.00
JOINT	219	482.00	-52.91	139.00
JOINT	220	482.00	-52.96	121.00
JOINT	221	482.00	-50.79	97.00
JOINT	222	482.00	-48.00	92.00
JOINT	223	482.00	-35.70	87.60
JOINT	224	482.00	-22.86	87.10
JOINT	225	482.00	-10.96	87.00
JOINT	226	482.00	.00	87.00
JOINT	227	482.00	10.96	87.00
JOINT	228	482.00	22.86	87.10
JOINT	229	482.00	35.70	87.60
JOINT	230	482.00	48.00	92.00
JOINT	231	482.00	50.79	97.00
JOINT	232	482.00	52.96	121.00
JOINT	233	482.00	52.91	139.00
JOINT	234	482.00	52.37	157.00
JOINT	235	482.00	51.98	163.00
JOINT	236	482.00	51.38	169.00
JOINT	237	482.00	43.50	184.00
JOINT	238	482.00	31.81	189.70
JOINT	239	482.00	20.00	191.00
JOINT	240	482.00	6.75	191.00
JOINT	241	462.00	-.00	191.00
JOINT	242	462.00	-6.75	191.00
JOINT	243	462.00	-20.00	191.00
JOINT	244	462.00	-31.81	189.70
JOINT	245	462.00	-43.50	184.00
JOINT	246	462.00	-51.38	169.00
JOINT	247	462.00	-51.98	163.00
JOINT	248	462.00	-52.38	157.00
JOINT	249	462.00	-52.91	139.00
JOINT	250	462.00	-52.96	121.00

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT		F.S.	B.L.	W.L.
JOINT	251	462.00	-50.79	97.00
JOINT	252	462.00	-48.00	92.00
JOINT	253	462.00	-35.70	87.60
JOINT	254	462.00	-22.86	87.10
JOINT	255	462.00	-10.96	87.00
JOINT	256	462.00	.00	87.00
JOINT	257	462.00	10.96	87.00
JOINT	258	462.00	22.86	87.10
JOINT	259	462.00	35.70	87.60
JOINT	260	462.00	48.00	92.00
JOINT	261	462.00	50.79	97.00
JOINT	262	462.00	52.96	121.00
JOINT	263	462.00	52.91	139.00
JOINT	264	462.00	52.37	157.00
JOINT	265	462.00	51.98	163.00
JOINT	266	462.00	51.38	169.00
JOINT	267	462.00	43.50	184.00
JOINT	268	462.00	31.81	189.70
JOINT	269	462.00	20.00	191.00
JOINT	270	462.00	6.75	191.00
JOINT	271	442.00	-.00	191.00
JOINT	272	442.00	-6.75	191.00
JOINT	273	442.00	-20.00	191.00
JOINT	274	442.00	-31.81	189.70
JOINT	275	442.00	-43.50	184.00
JOINT	276	442.00	-51.38	169.00
JOINT	277	442.00	-51.98	163.00
JOINT	278	442.00	-52.38	157.00
JOINT	279	442.00	-52.91	139.00
JOINT	280	442.00	-52.96	121.00
JOINT	281	442.00	-50.79	97.00
JOINT	282	442.00	-48.00	92.00
JOINT	283	442.00	-35.70	87.60
JOINT	284	442.00	-22.86	87.10
JOINT	285	442.00	-10.96	87.00
JOINT	286	442.00	.00	87.00
JOINT	287	442.00	10.96	87.00
JOINT	288	442.00	22.86	87.10
JOINT	289	442.00	35.70	87.60
JOINT	290	442.00	48.00	92.00
JOINT	291	442.00	50.79	97.00
JOINT	292	442.00	52.96	121.00
JOINT	293	442.00	52.91	139.00
JOINT	294	442.00	52.37	157.00
JOINT	295	442.00	51.98	163.00
JOINT	296	442.00	51.38	169.00
JOINT	297	442.00	43.50	1[illegible]4.00
JOINT	298	442.00	31.81	189.70
JOINT	299	442.00	20.00	191.00
JOINT	300	442.00	6.75	191.00

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

JOINT	F.S.	B.L.	W.L.
JOINT 301	632.00	.00	178.00
JOINT 302	538.25	-50.70	102.37
JOINT 303	538.25	50.70	102.37

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 1

MEMBER			AREA	I
MEMBER	1	2	.352	.6850
MEMBER	2	3	.578	3.7070
MEMBER	3	4	.574	3.3700
MEMBER	4	5	.420	2.3000
MEMBER	5	6	.330	.5500
MEMBER	6	7	.250	.4040
MEMBER	7	8	.220	.3500
MEMBER	8	9	.194	.3030
MEMBER	9	10	.194	.3030
MEMBER	10	11	.194	.3030
MEMBER	11	12	.256	.3870
MEMBER	12	13	.143	.0980
MEMBER	13	14	.139	.0880
MEMBER	14	15	.139	.0880
MEMBER	15	16	.139	.0880
MEMBER	16	17	.139	.0880
MEMBER	17	18	.139	.0880
MEMBER	18	19	.139	.0880
MEMBER	19	20	.143	.0980
MEMBER	20	21	.256	.3870
MEMBER	21	22	.194	.3030
MEMBER	22	23	.194	.3030
MEMBER	23	24	.194	.3030
MEMBER	24	25	.220	.3500
MEMBER	25	26	.250	.4040
MEMBER	26	27	.330	.5500
MEMBER	27	28	.420	2.3000
MEMBER	28	29	.574	3.3700
MEMBER	29	30	.578	3.7070
MEMBER	30	1	.352	.6850

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 2

MEMBER			AREA	PANEL THICKNESS
MEMBER	1	31	.339	.0250
MEMBER	2	32	.627	.0360
MEMBER	3	33	.621	.0400
MEMBER	4	34	.493	.0400
MEMBER	5	35	.830	.0400
MEMBER	6	36	1.505	.0400
MEMBER	7	37	.363	.0400
MEMBER	8	38	.585	.0400
MEMBER	9	39	.393	.0400
MEMBER	10	40	.052	.0400
MEMBER	11	41	1.167	.0000
MEMBER	12	42	.595	.0320
MEMBER	13	43	.379	.0320
MEMBER	14	44	.394	.0320
MEMBER	15	45	.500	.0560
MEMBER	16	46	.443	.0560
MEMBER	17	47	.500	.0320
MEMBER	18	48	.394	.0320
MEMBER	19	49	.379	.0320
MEMBER	20	50	.595	.0000
MEMBER	21	51	1.059	.0350
MEMBER	22	52	.045	.0350
MEMBER	23	53	.340	.0350
MEMBER	24	54	.504	.0350
MEMBER	25	55	.316	.0350
MEMBER	26	56	1.487	.0400
MEMBER	27	57	.830	.0400
MEMBER	28	58	.493	.0400
MEMBER	29	59	.594	.0320
MEMBER	30	60	.330	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 3

MEMBER			AREA	I
MEMBER	31	32	.643	.2560
MEMBER	32	33	.598	2.1930
MEMBER	33	34	.725	1.3510
MEMBER	34	35	.590	.6830
MEMBER	35	36	.820	1.8670
MEMBER	36	37	.668	1.5100
MEMBER	37	38	.480	1.0000
MEMBER	38	39	.510	1.4400
MEMBER	39	40	.530	2.0200
MEMBER	40	41	.530	2.0200
MEMBER	41	42	.168	.0130
MEMBER	42	43	.306	.0130
MEMBER	43	44	.337	.0130
MEMBER	44	45	.334	.0130
MEMBER	45	46	.343	.0130
MEMBER	46	47	.343	.0130
MEMBER	47	48	.334	.0130
MEMBER	48	49	.337	.0130
MEMBER	49	50	.306	.0130
MEMBER	50	51	.168	.0130
MEMBER	51	52	.530	2.0200
MEMBER	52	53	.530	2.0200
MEMBER	53	54	.510	1.4400
MEMBER	54	55	.480	1.0000
MEMBER	55	56	.668	1.5100
MEMBER	56	57	.820	1.8670
MEMBER	57	58	.590	.6830
MEMBER	58	59	.725	1.3510
MEMBER	59	60	.598	2.1930
MEMBER	60	31	.543	.1950

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 4

MEMBER	AREA	PANEL THICKNESS
MEMBER 31 61	.340	.0250
MEMBER 32 62	.658	.0320
MEMBER 33 63	.511	.0250
MEMBER 34 64	.392	.0250
MEMBER 35 65	.596	.0250
MEMBER 36 66	.523	.0250
MEMBER 37 67	.221	.0250
MEMBER 38 68	.426	.0250
MEMBER 39 69	.584	.0250
MEMBER 40 70	.114	.0250
MEMBER 41 71	1.213	.0000
MEMBER 42 72	.000	.0000
MEMBER 43 73	.000	.0000
MEMBER 44 74	.000	.0000
MEMBER 45 75	.000	.0000
MEMBER 46 76	.000	.0000
MEMBER 47 77	.000	.0000
MEMBER 48 78	.000	.0000
MEMBER 49 79	.000	.0000
MEMBER 50 80	.000	.0000
MEMBER 51 81	1.098	.0250
MEMBER 52 82	.114	.0250
MEMBER 53 83	.585	.0250
MEMBER 54 84	.426	.0250
MEMBER 55 85	.365	.0250
MEMBER 56 86	.502	.0250
MEMBER 57 87	.473	.0250
MEMBER 58 88	.392	.0250
MEMBER 59 89	.511	.0320
MEMBER 60 90	.377	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 5

MEMBER			AREA	I
MEMBER	61	62	.240	.4900
MEMBER	62	63	.400	1.9600
MEMBER	63	64	.360	1.5500
MEMBER	64	65	.227	.6500
MEMBER	65	66	.158	.2700
MEMBER	66	67	.152	.2390
MEMBER	67	68	.152	.2390
MEMBER	68	69	.152	.2390
MEMBER	69	70	.310	1.5000
MEMBER	70	71	.390	1.8300
MEMBER	71	72	-.000	-.0000
MEMBER	72	73	-.000	-.0000
MEMBER	73	74	-.000	-.0000
MEMBER	74	75	-.000	-.0000
MEMBER	75	76	.000	.0000
MEMBER	76	77	-.000	-.0000
MEMBER	77	78	.000	.0000
MEMBER	78	79	-.000	-.0000
MEMBER	79	80	.000	-.0000
MEMBER	80	81	-.000	-.0000
MEMBER	81	82	.390	1.8300
MEMBER	82	83	.310	1.5000
MEMBER	83	84	.152	.2390
MEMBER	84	85	.152	.2390
MEMBER	85	86	.152	.2390
MEMBER	86	87	.158	.2700
MEMBER	87	88	.227	.6500
MEMBER	88	89	.360	1.5500
MEMBER	89	90	.400	1.9600
MEMBER	90	61	.240	.4900

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 6

MEMBER			AREA	PANEL THICKNESS
MEMBER	61	91	.340	.0250
MEMBER	62	92	.640	.0320
MEMBER	63	93	.546	.0250
MEMBER	64	94	.431	.0250
MEMBER	65	95	.587	.0250
MEMBER	66	96	.504	.0250
MEMBER	67	97	.214	.0250
MEMBER	68	98	.426	.0250
MEMBER	69	99	.754	.0250
MEMBER	70	100	.312	.0250
MEMBER	71	101	1.266	.0000
MEMBER	72	102	.000	.0000
MEMBER	73	103	.000	.0000
MEMBER	74	104	.000	.0000
MEMBER	75	105	.000	.0000
MEMBER	76	106	.000	.0000
MEMBER	77	107	.000	.0000
MEMBER	78	108	.000	.0000
MEMBER	79	109	.000	.0000
MEMBER	80	110	.000	.0000
MEMBER	81	111	1.143	.0250
MEMBER	82	112	.353	.0250
MEMBER	83	113	.754	.0250
MEMBER	84	114	.426	.0250
MEMBER	85	115	.349	.0250
MEMBER	86	116	.483	.0250
MEMBER	87	117	.473	.0250
MEMBER	88	118	.431	.0250
MEMBER	89	119	.546	.0320
MEMBER	90	120	.387	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 7

MEMBER			AREA	I
MEMBER	91	92	.240	.5000
MEMBER	92	93	.365	1.4400
MEMBER	93	94	.319	1.1200
MEMBER	94	95	.240	.6000
MEMBER	95	96	.280	.6000
MEMBER	96	97	.340	.6500
MEMBER	97	98	.316	.6500
MEMBER	98	99	.360	.6800
MEMBER	99	100	.380	1.5000
MEMBER	100	101	.400	2.5000
MEMBER	101	102	-.000	-.0000
MEMBER	102	103	-.000	-.0000
MEMBER	103	104	-.000	-.0000
MEMBER	104	105	-.000	-.0000
MEMBER	105	106	.000	.0000
MEMBER	106	107	-.000	-.0000
MEMBER	107	108	.000	.0000
MEMBER	108	109	-.000	-.0000
MEMBER	109	110	-.000	-.0000
MEMBER	110	111	-.000	-.0000
MEMBER	111	112	.400	2.5000
MEMBER	112	113	.380	1.5000
MEMBER	113	114	.360	.6800
MEMBER	114	115	.316	.6500
MEMBER	115	116	.340	.6500
MEMBER	116	117	.280	.6000
MEMBER	117	118	.240	.6000
MEMBER	118	119	.319	1.1200
MEMBER	119	120	.365	1.4400
MEMBER	120	91	.240	.5000

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 8

MEMBER	AREA	PANEL THICKNESS
MEMBER 91 121	.340	.0250
MEMBER 92 122	.596	.0320
MEMBER 93 123	.560	.0250
MEMBER 94 124	.446	.0250
MEMBER 95 125	.582	.0250
MEMBER 96 126	.498	.0250
MEMBER 97 127	.214	.0250
MEMBER 98 128	.426	.0250
MEMBER 99 129	.818	.0250
MEMBER 100 130	.480	.0250
MEMBER 101 131	1.366	.0000
MEMBER 102 132	.000	.0000
MEMBER 103 133	.000	.0000
MEMBER 104 134	.000	.0000
MEMBER 105 135	.000	.0000
MEMBER 106 136	.000	.0000
MEMBER 107 137	.000	.0000
MEMBER 108 138	.000	.0000
MEMBER 109 139	.000	.0000
MEMBER 110 140	.000	.0000
MEMBER 111 141	1.244	.0250
MEMBER 112 142	.481	.0250
MEMBER 113 143	.818	.0250
MEMBER 114 144	.426	.0250
MEMBER 115 145	.347	.0250
MEMBER 116 146	.477	.0250
MEMBER 117 147	.469	.0250
MEMBER 118 148	.446	.0250
MEMBER 119 149	.560	.0320
MEMBER 120 150	.386	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 9

MEMBER			AREA	I
MEMBER	121	122	.290	.9000
MEMBER	122	123	.370	1.5700
MEMBER	123	124	.324	1.1600
MEMBER	124	125	.270	.7500
MEMBER	125	126	.233	.5600
MEMBER	126	127	.240	.4000
MEMBER	127	128	.313	.6000
MEMBER	128	129	.360	.6200
MEMBER	129	130	.480	1.5000
MEMBER	130	131	.490	3.0000
MEMBER	131	132	-.000	-.0000
MEMBER	132	133	-.000	-.0000
MEMBER	133	134	-.000	-.0000
MEMBER	134	135	-.000	-.0000
MEMBER	135	136	.000	.0000
MEMBER	136	137	-.000	-.0000
MEMBER	137	138	-.000	-.0000
MEMBER	138	139	.000	.0000
MEMBER	139	140	-.000	-.0000
MEMBER	140	141	-.000	-.0000
MEMBER	141	142	.490	3.0000
MEMBER	142	143	.480	1.5000
MEMBER	143	144	.360	.6200
MEMBER	144	145	.313	.6000
MEMBER	145	146	.240	.4000
MEMBER	146	147	.233	.5600
MEMBER	147	148	.270	.7500
MEMBER	148	149	.324	1.1600
MEMBER	149	150	.370	1.5700
MEMBER	150	121	.290	.9000

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 10

MEMBER	AREA	PANEL THICKNESS
MEMBER 121 151	.340	.0250
MEMBER 122 152	.543	.0320
MEMBER 123 153	.574	.0250
MEMBER 124 154	.460	.0250
MEMBER 125 155	.578	.0250
MEMBER 126 156	.510	.0250
MEMBER 127 157	.214	.0250
MEMBER 128 158	.426	.0250
MEMBER 129 159	.818	.0250
MEMBER 130 160	.667	.0250
MEMBER 131 161	1.524	.0000
MEMBER 132 162	.000	.0000
MEMBER 133 163	.000	.0000
MEMBER 134 164	.000	.0000
MEMBER 135 165	.000	.0000
MEMBER 136 166	.000	.0000
MEMBER 137 167	.000	.0000
MEMBER 138 168	.000	.0000
MEMBER 139 169	.000	.0000
MEMBER 140 170	.000	.0000
MEMBER 141 171	1.406	.0250
MEMBER 142 172	.664	.0250
MEMBER 143 173	.818	.0250
MEMBER 144 174	.426	.0250
MEMBER 145 175	.355	.0250
MEMBER 146 176	.480	.0250
MEMBER 147 177	.466	.0250
MEMBER 148 178	.430	.0290
MEMBER 149 179	.594	.0320
MEMBER 150 180	.386	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 11

MEMBER	AREA	I
MEMBER 151 152	.860	6.4000
MEMBER 152 153	.810	6.6000
MEMBER 153 154	.875	6.4000
MEMBER 154 155	.710	3.9000
MEMBER 155 156	.670	2.7200
MEMBER 156 157	.660	2.1800
MEMBER 157 158	.660	2.1800
MEMBER 158 159	.660	2.1800
MEMBER 159 160	.660	2.1800
MEMBER 160 161	1.250	4.7200
MEMBER 161 162	1.225	5.0000
MEMBER 162 163	1.225	5.0000
MEMBER 163 164	.850	6.3800
MEMBER 164 165	.680	6.1700
MEMBER 165 166	.680	6.1700
MEMBER 166 167	.680	6.1700
MEMBER 167 168	.680	6.1700
MEMBER 168 169	.850	6.3800
MEMBER 169 170	1.225	5.0000
MEMBER 170 171	1.225	5.0000
MEMBER 171 172	1.250	4.7200
MEMBER 172 173	.660	2.1800
MEMBER 173 174	.660	2.1800
MEMBER 174 175	.660	2.1800
MEMBER 175 176	.660	2.1800
MEMBER 176 177	.670	2.7200
MEMBER 177 178	.710	3.9000
MEMBER 178 179	.875	6.4000
MEMBER 179 180	.810	6.6000
MEMBER 180 151	.860	6.4000

TABLE 27 (continued)

RAMP AREA COEFF IN 9 PAY EXTENDED

UNIT 12

MEMBER	AREA	PANEL THICKNESS
MEMBER 151 181	.232	.0250
MEMBER 152 182	.367	.0250
MEMBER 153 183	.471	.0250
MEMBER 154 184	.468	.0250
MEMBER 155 185	.562	.0250
MEMBER 156 186	.450	.0250
MEMBER 157 187	.250	.0320
MEMBER 158 188	.510	.0320
MEMBER 159 189	.726	.0240
MEMBER 160 190	.779	.0240
MEMBER 161 191	.817	.0500
MEMBER 162 192	.601	.0400
MEMBER 163 193	.779	.0400
MEMBER 164 194	.663	.0250
MEMBER 165 195	.680	.0250
MEMBER 166 196	.668	.0250
MEMBER 167 197	.543	.0250
MEMBER 168 198	.663	.0400
MEMBER 169 199	.779	.0400
MEMBER 170 200	.601	.0500
MEMBER 171 201	.817	.0240
MEMBER 172 202	.779	.0240
MEMBER 173 203	.726	.0320
MEMBER 174 204	.510	.0320
MEMBER 175 205	.250	.0250
MEMBER 176 206	.427	.0250
MEMBER 177 207	.569	.0250
MEMBER 178 208	.468	.0250
MEMBER 179 209	.471	.0250
MEMBER 180 210	.367	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 13

MEMBER	AREA	I
MEMBER 181 182	.290	1.6000
MEMBER 182 183	.290	1.6000
MEMBER 183 184	.297	1.6250
MEMBER 184 185	.320	.9200
MEMBER 185 186	.375	.8000
MEMBER 186 187	.325	.6000
MEMBER 187 188	.310	.5900
MEMBER 188 189	.310	.5900
MEMBER 189 190	.375	.7700
MEMBER 190 191	1.075	3.2600
MEMBER 191 192	1.800	5.6700
MEMBER 192 193	1.150	6.6000
MEMBER 193 194	.900	8.6000
MEMBER 194 195	.875	9.3000
MEMBER 195 196	.890	9.7600
MEMBER 196 197	.890	9.7600
MEMBER 197 198	.875	9.3000
MEMBER 198 199	.900	8.6000
MEMBER 199 200	1.150	6.6000
MEMBER 200 201	1.800	5.6700
MEMBER 201 202	1.075	3.2600
MEMBER 202 203	.375	.7700
MEMBER 203 204	.310	.5900
MEMBER 204 205	.310	.5900
MEMBER 205 206	.325	.6000
MEMBER 206 207	.375	.8000
MEMBER 207 208	.320	.9200
MEMBER 208 209	.320	1.9000
MEMBER 209 210	.290	1.6000
MEMBER 210 181	.290	1.6000

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 14

MEMBER	AREA	PANEL THICKNESS
MEMBER 181 211	.232	.0250
MEMBER 182 212	.367	.0250
MEMBER 183 213	.471	.0250
MEMBER 184 214	.468	.0250
MEMBER 185 215	.562	.0250
MEMBER 186 216	.471	.0320
MEMBER 187 217	.175	.0000
MEMBER 188 218	.000	.0000
MEMBER 189 219	.423	.0300
MEMBER 190 220	.888	.0290
MEMBER 191 221	.782	.0500
MEMBER 192 222	.559	.0400
MEMBER 193 223	.722	.0400
MEMBER 194 224	.606	.0250
MEMBER 195 225	.623	.0250
MEMBER 196 226	.611	.0250
MEMBER 197 227	.486	.0250
MEMBER 198 228	.606	.0400
MEMBER 199 229	.722	.0400
MEMBER 200 230	.559	.0500
MEMBER 201 231	.782	.0290
MEMBER 202 232	.888	.0300
MEMBER 203 233	.423	.0000
MEMBER 204 234	.000	.0000
MEMBER 205 235	.175	.0320
MEMBER 206 236	.448	.0250
MEMBER 207 237	.569	.0250
MEMBER 208 238	.468	.0250
MEMBER 209 239	.471	.0250
MEMBER 210 240	.367	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 15

MEMBER	AREA	I
MEMBER 211 212	.290	1.6000
MEMBER 212 213	.290	1.6000
MEMBER 213 214	.297	1.6250
MEMBER 214 215	.320	.9200
MEMBER 215 216	.375	.8000
MEMBER 216 217	.325	.6000
MEMBER 217 218	.310	.5900
MEMBER 218 219	.310	.5900
MEMBER 219 220	.375	.7700
MEMBER 220 221	1.075	3.2600
MEMBER 221 222	1.800	5.6700
MEMBER 222 223	1.150	6.6000
MEMBER 223 224	.900	8.6000
MEMBER 224 225	.875	9.3000
MEMBER 225 226	.890	9.7600
MEMBER 226 227	.890	9.7600
MEMBER 227 228	.875	9.3000
MEMBER 228 229	.900	8.6000
MEMBER 229 230	1.150	6.6000
MEMBER 230 231	1.800	5.6700
MEMBER 231 232	1.075	3.2600
MEMBER 232 233	.375	.7700
MEMBER 233 234	.310	.5900
MEMBER 234 235	.310	.5900
MEMBER 235 236	.325	.6000
MEMBER 236 237	.375	.8000
MEMBER 237 238	.320	.9200
MEMBER 238 239	.320	1.9000
MEMBER 239 240	.290	1.6000
MEMBER 240 211	.290	1.6000

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 16

MEMBER	AREA	PANEL THICKNESS
MEMBER 211 241	.232	.0250
MEMBER 212 242	.367	.0250
MEMBER 213 243	.471	.0250
MEMBER 214 244	.468	.0250
MEMBER 215 245	.562	.0250
MEMBER 216 246	.450	.0250
MEMBER 217 247	.250	.0320
MEMBER 218 248	.510	.0320
MEMBER 219 249	.732	.0250
MEMBER 220 250	.821	.0270
MEMBER 221 251	.590	.0250
MEMBER 222 252	.387	.0250
MEMBER 223 253	.527	.0250
MEMBER 224 254	.509	.0250
MEMBER 225 255	.623	.0250
MEMBER 226 256	.611	.0250
MEMBER 227 257	.486	.0250
MEMBER 228 258	.509	.0250
MEMBER 229 259	.527	.0250
MEMBER 230 260	.387	.0250
MEMBER 231 261	.590	.0270
MEMBER 232 262	.821	.0250
MEMBER 233 263	.732	.0320
MEMBER 234 264	.510	.0320
MEMBER 235 265	.250	.0250
MEMBER 236 266	.427	.0250
MEMBER 237 267	.569	.0250
MEMBER 238 268	.468	.0250
MEMBER 239 269	.471	.0250
MEMBER 240 270	.367	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 17

MEMBER	AREA	I
MEMBER 241 242	.345	[illegible]
MEMBER 242 243	.345	[illegible]
MEMBER 243 244	.400	2.4500
MEMBER 244 245	.384	1.2100
MEMBER 245 246	.450	1.0500
MEMBER 246 247	.369	.7400
MEMBER 247 248	.369	.7400
MEMBER 248 249	.369	.7400
MEMBER 249 250	.510	1.0770
MEMBER 250 251	1.075	3.2600
MEMBER 251 252	1.800	5.6700
MEMBER 252 253	1.150	6.6000
MEMBER 253 254	.920	8.5000
MEMBER 254 255	.900	9.6000
MEMBER 255 256	.890	9.6000
MEMBER 256 257	.890	9.6000
MEMBER 257 258	.900	9.6000
MEMBER 258 259	.920	8.5000
MEMBER 259 260	1.150	6.6000
MEMBER 260 261	1.800	5.6700
MEMBER 261 262	1.075	3.2600
MEMBER 262 263	.510	1.0770
MEMBER 263 264	.369	.7400
MEMBER 264 265	.369	.7400
MEMBER 265 266	.369	.7400
MEMBER 266 267	.450	1.0500
MEMBER 267 268	.384	1.2100
MEMBER 268 269	.400	2.4500
MEMBER 269 270	.345	2.0700
MEMBER 270 241	.345	2.0700

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 18

MEMBER	AREA	PANEL THICKNESS
MEMBER 241 271	.232	.0250
MEMBER 242 272	.367	.0250
MEMBER 243 273	.471	.0250
MEMBER 244 274	.468	.0250
MEMBER 245 275	.562	.0250
MEMBER 246 276	.450	.0250
MEMBER 247 277	.229	.0250
MEMBER 248 278	.426	.0250
MEMBER 249 279	.669	.0250
MEMBER 250 280	.821	.0270
MEMBER 251 281	.590	.0250
MEMBER 252 282	.387	.0250
MEMBER 253 283	.527	.0250
MEMBER 254 284	.509	.0250
MEMBER 255 285	.623	.0250
MEMBER 256 286	.611	.0250
MEMBER 257 287	.486	.0250
MEMBER 258 288	.509	.0250
MEMBER 259 289	.527	.0250
MEMBER 260 290	.387	.0250
MEMBER 261 291	.590	.0270
MEMBER 262 292	.821	.0250
MEMBER 263 293	.669	.0250
MEMBER 264 294	.426	.0250
MEMBER 265 295	.229	.0250
MEMBER 266 296	.427	.0250
MEMBER 267 297	.569	.0250
MEMBER 268 298	.468	.0250
MEMBER 269 299	.471	.0250
MEMBER 270 300	.367	.0250

TABLE 27 (continued)

RAMP AREA COEFF IN 9 BAY EXTENDED

UNIT 19

MEMBER	AREA	I
MEMBER 271 272	1.113	33.8200
MEMBER 272 273	1.113	33.8200
MEMBER 273 274	1.767	43.8500
MEMBER 274 275	2.470	40.5000
MEMBER 275 276	2.220	14.7500
MEMBER 276 277	2.280	20.1700
MEMBER 277 278	2.600	26.0000
MEMBER 278 279	3.530	36.8300
MEMBER 279 280	4.890	53.1600
MEMBER 280 281	6.870	159.3000
MEMBER 281 282	5.480	128.6000
MEMBER 282 283	4.910	39.3000
MEMBER 283 284	2.700	32.7000
MEMBER 284 285	1.546	20.5800
MEMBER 285 286	1.450	19.3700
MEMBER 286 287	1.470	18.9600
MEMBER 287 288	1.570	21.5900
MEMBER 288 289	2.700	32.7000
MEMBER 289 290	4.910	39.3000
MEMBER 290 291	5.480	128.6000
MEMBER 291 292	6.870	159.3000
MEMBER 292 293	4.890	53.1600
MEMBER 293 294	3.530	36.8300
MEMBER 294 295	2.600	26.0000
MEMBER 295 296	2.280	20.1700
MEMBER 296 297	2.220	14.7500
MEMBER 297 298	2.470	40.5000
MEMBER 298 299	1.767	45.0000
MEMBER 299 300	1.113	33.8200
MEMBER 300 271	1.113	33.8200

TABLE 28
PHASE I SHAKE TEST CORRELATION SUMMARY

TEST		ANALYSIS														
		18 Bay			9 Bay Soft Nose			9 Bay Stiff Nose			6 Bay 30 Stringer Reduced DOF			6 Bay 30 Stringer 60 Stringer		
Mode	Freq. (CPM)	Freq.	Δ	Shape	Freq.	Δ	Shape	Freq.	Δ	Shape	Freq.	Δ	Shape	Freq.	Δ	Shape
1st Lateral	910	1207	33%	G	1466	60%	P	1473	62%	P	1435	58%	P	1440	58%	P
1st Vertical	1155	1175	2%	E	1282	11%	E	1284	11%	E	1242	8%	E	1241	8%	E
XSSN Pitch	1490	1709	13%	E	1710	13%	E	1715	13%	E	1748	17%	E	1758	17%	E
2nd Vertical	1950	2150	10%	G	2390	22%	F	2390	22%	F	2505	28%	F	2577	32%	F
XSSN Roll	2000	2405	20%	P	2870	43%	P	2870	43%	P	2900	45%	P	2894	45%	P
XSSN Vertical	2150	2250	4%	F												
Torsion	2300	2763	20%	F	2428	6%	P/F	2428	6%	P/F	2442	6%	P/F	2445	6%	P/F

TABLE 29

FRAN PHASE II

APPENDAGE MASS DATA SUMMARY CH-53A

PARAMETER		ADAPTER AND LOWER PLATE	SHAKER	MAIN GEAR -BOX HOUSING
WEIGHT, (LBS)		541.	410.	601.
X_{cg},	F. STA.	336.3	336.0	339.8
Y_{cg}	F. B.L.	0.	0.	0.
Z_{cg}	F. W.L.	257.0	264.0	207.8
I_{ox},	LB. IN^2	56,954.	24,860.	134,408.
I_{oy}	LB. IN^2	125,301.	7,946.	134,408.
I_{oz},	LB. IN^2	182,831.	16,914.	180,025.

PARAMETER		MAIN GEAR -BOX BALLAST	TAIL BALLAST	NOSE BALLAST
WEIGHT, (LBS)		4.570.	1,500.	3,300.
X_{cg},	F. STA.	338.8	758.	110.
Y_{cg},	F. B.L.	0.	0.	0.
Z_{cg},	F. W.L.	230.	186.4	84.
I_{ox},	LB. IN^2	384,000.	151,200.	845,000.
I_{oy} ,	LB. IN^2	2,700,000.	62,900.	905,000.
I_{oz},	LB. IN^2	2,920,000.	195,200.	1,700,000.

TABLE 30

PHASE II EIGHTEEN BAY DEGREE OF FREEDOM MODEL RIGID BALLAST MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	9.4460	2	1.1718	3	.8784
4	15.8400	-0	-.0000	-0	-.0000
160	.3633	5	.3739	-0	-.0000
6	4.3600	7	10.8020	-0	-.0000
8	15.8400	-0	-.0000	-0	-.0000
9	15.8400	-0	-.0000	-0	-.0000
10	4390.0000	-0	-.0000	-0	-.0000
11	4.5420	12	9.4460	-0	-.0000
13	1.1718	14	.7264	15	.4572
190	.3633	16	.3739	17	4.3600
18	5334.0000	19	2440.0000	20	2155.0000
21	1377.0000	138	935.0000	-0	-.0000
191	567.0000	22	263.0000	-0	-.0000
23	577.0000	24	4886.0000	25	1215.9999
26	1584.9999	27	10600.9999	139	1175.9999
28	42.0000	29	252.0000	30	5025.0000
31	1228.0000	32	1096.9999	33	626.0000
193	458.0000	34	274.0000	35	579.0000
36	.6129	-0	-.0000	-0	-.0000
37	.0346	38	.0346	39	.0618
40	.0367	41	.0367	42	.0618
43	.0475	44	.0475	-0	-.0000
45	.0858	46	.0412	47	.0412
48	.0858	49	.1709	50	.0441
51	.0441	52	.1709	53	.0934
54	.0641	55	.0641	56	.0934
57	.1535	58	.0503	59	.0503
60	.1535	61	.0357	62	.0357
63	.1100	64	.0551	65	.0551
66	.1100	-0	-.0000	-0	-.0000
67	.0392	68	.0392	69	.1041
70	.0523	71	.0523	72	.1045
73	.8351	74	1.4396	-0	-.0000
75	.1295	76	.1167	77	.1193
78	.1167	79	.1709	80	.0882
81	.1709	82	.0934	83	.1282
84	.0934	85	.1535	86	.1005
87	.1535	88	.0714	89	.1100
90	.1101	91	.1100	-0	-.0000
92	.0785	93	.1041	94	.1045
95	.1041	96	.8351	-0	-.0000

TABLE 30 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
97	.3079	137	.8351	-0	-.0000
98	.0693	99	.0327	100	.0291
101	.0735	102	.0291	103	.0327
104	.0949	105	.0443	-0	-.0000
106	.0416	107	.0825	108	.0416
109	.0443	110	.1164	111	.0392
112	.0882	113	.0392	114	.1164
115	.0466	116	.0468	117	.1282
118	.0468	119	.0466	120	.1001
121	.0534	122	.1005	123	.0534
124	.1001	125	.0714	126	.0551
127	.0570	128	.1101	129	.0570
130	.0531	-0	-.0000	-0	-.0000
131	.0785	132	.0563	133	.0479
134	.1045	135	.0479	136	.0563
140	391.0000	-0	-.0000	-0	-.0000
141	2531.0000	142	1351.0000	143	1188.9999
144	.0629	145	.0629	146	.0938
147	.0890	148	.0890	149	.0938
150	.0350	151	.0350	152	.0706
153	.0529	154	.0529	155	.0706
156	.0610	157	.0610	158	.2415
159	.2415	-0	-.0000	-0	-.0000
161	.1259	162	.0938	163	.1781
164	.0938	165	.0700	166	.0706
167	.1057	168	.0706	169	.1220
170	.2415	171	.2415	-0	-.0000
172	.5453	-0	-.0000	-0	-.0000
173	.1259	174	.0558	175	.0379
176	.1781	177	.0379	178	.0558
179	.0700	180	.0369	181	.0337
182	.1057	183	.0337	184	.0369
185	.1220	186	.1410	187	-.0000
188	-.0000	189	.1410	-0	-.0000
192	155.0000	-0	-.0000	-0	-.0000
194	.6147	195	.6147	196	.6147
197	564.625	198	217.6700	199	9515.0000

TABLE 31
FINAL CONFIGURATION EIGHTEEN BAY FLEXIBLE NOSE AND TAIL BALLAST
MODEL MASS MATRIX

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
1	5.2165	2	1.1718	3	.8784
4	15.8400	-0	-.0000	-0	-.0000
36	.6129	-0	-.0000	-0	-.0000
160	.3633	5	.3739	-0	-.0000
6	.4715	7	10.8020	-0	-.0000
8	15.8400	-0	-.0000	-0	-.0000
9	15.8400	-0	-.0000	-0	-.0000
10	4390.0000	-0	-.0000	-0	-.0000
11	.6585	12	9.4460	-0	-.0000
13	1.1718	14	.8788	15	3.8900
190	.3633	16	.3739	17	4.3600
18	5334.0000	19	2440.0000	20	2614.0000
21	3.8900	138	1853.0000	-0	-.0000
191	567.0000	22	263.0000	-0	-.0000
23	577.0000	24	3343.0000	25	1215.9999
26	1584.9999	27	10600.9999	139	1175.9999
28	145.0000	29	66.0000	30	5025.0000
31	1228.0000	32	1549.9999	33	163.0000
193	595.0000	34	4.2300	35	716.0000
37	.0346	38	.0346	39	.0618
40	.0367	41	.0367	42	.0618
43	.0475	44	.0475	-0	-.0000
45	.0858	46	.0412	47	.0412
48	.0858	49	.1709	50	.0441
51	.0441	52	.1709	53	.0934
54	.0641	55	.0641	56	.0934
57	.1535	58	.0503	59	.0503
60	.1535	61	.0357	62	.0357
63	.1100	64	.0551	65	.0551
66	.1100	-0	-.0000	-0	-.0000
67	.0392	68	.0392	69	.1041
70	.0523	71	.0523	72	.1045
73	.8351	74	1.4396	-0	-.0000
75	.1295	76	.1167	77	.1193
78	.1167	79	.1709	80	.0882
81	.1709	82	.0934	83	.1282
84	.0934	85	.1535	86	.1005
87	.1535	88	.0714	89	.1100
90	.1101	91	.1100	-0	-.0000
92	.0785	93	.1041	94	.1045
95	.1041	96	.8351	-0	-.0000

TABLE 31 (continued)

D.O.F.	MASS	D.O.F.	MASS	D.O.F.	MASS
97	.6127	137	.8351	-0	-.0000
98	.0693	99	.0327	100	.0291
101	.0735	102	.0291	103	.0327
104	.0949	105	.0443	-0	-.0000
106	.0416	107	.0825	108	.0416
109	.0443	110	.1164	111	.0392
112	.0882	113	.0392	114	.1164
115	.0466	116	.0468	117	.1282
118	.0468	119	.0466	120	.1001
121	.0534	122	.1005	123	.0534
124	.1001	125	.0714	126	.0551
127	.0570	128	.1101	129	.0570
130	.0531	-0	-.0000	-0	-.0000
131	.0785	132	.0563	133	.0479
134	.1045	135	.0479	136	.0563
140	930.0000	-0	-.0000	-0	-.0000
141	2531.0000	142	1351.0000	143	1188.9999
144	.0629	145	.0629	146	.0938
147	.0890	148	.0890	149	.0938
150	.0350	151	.0350	152	.0706
153	.0529	154	.0529	155	.0706
156	.0610	157	.0610	158	.2415
159	.2415	-0	-.0000	-0	-.0000
161	.1259	162	.0938	163	.1781
164	.0938	165	.0700	166	.0706
167	.1057	168	.0706	169	.1220
170	.2415	171	.2415	-0	-.0000
172	.5453	-0	-.0000	-0	-.0000
173	.1259	174	.0558	175	.0379
176	.1781	177	.0379	178	.0558
179	.0706	180	.0369	181	.0337
182	.1057	183	.0337	184	.0369
185	.1220	186	.1410	187	-.0000
188	-.0000	139	.1410	-0	-.0000
192	176.0000	-0	-.0000	-0	-.0000
194	.6147	195	.6147	196	.6147
197	564.6250	198	217.6700	199	9315.0000

TABLE 32

PHASE II CORRELATION SUMMARY

VERTICAL/PITCH MODES

MODE	Frequency (CPM) Test	Analysis	Error	Shape
1st Vertical Bending	440	438	0%	E
Transmission Pitch	740	751	1.5%	G
Nose Block Vertical/ Transmission Pitch	970	933	4%	G
Nose Block Vertical	1050	1043	1%	F
Second Vertical	1290	1523	17%	F
Transmission Vertical/ Ramp Vertical	1425	1563	10%	F/G
Ramp Vertical	1640	1394	18%	P

LATERAL/TORSION MODES

MODE	Test	Analysis	Error	Shape
1st Lateral Bending	615	659	7	G
Forward Cabin Lateral	840	735	12	P
Nose Block Lateral	930	858	8	P
Forward Cabin Lateral/ Nose Block Lateral	990	1105	12	P
Torsion	1310	1601	23	P